School of Computing Science and Engineering

Program: B.C.A.

Course Code: BCAS3003

Course Name: Computer Graphics

Vision

To be known globally as a premier department of Computer Science and Engineering for value-based education, multidisciplinary research and innovation.

Mission

- **M1:** Developing a strong foundation in fundamentals of computing science with responsiveness towards emerging technologies.
- **M2:** Establishing state-of-the-art facilities and adopt education 4.0 practices to analyze, develop, test and deploy sustainable ethical IT solutions by involving multiple stakeholders.
- **M3:** Establishing Centers of Excellence for multidisciplinary collaborative research in association with industry and academia.

Course Outcomes (COs)

CO Number	Title
CO1	Describe the fundamental concepts of Computer Graphics. (K1)
CO2	To demonstrate with the relevant mathematics of computer graphics, ex. line, circle and ellipse drawing algorithms. (K3)
CO3	To understand the attributes of output primitives of Graphics. (K2).
CO4	Apply simple and composite transformation on graphic objects/elements in two dimensions. (K3).
CO5	Analyze two dimensions modeling and clipping techniques. (K4).
CO6	List out the various contemporary research areas and tool in graphics domain. (K2).

Course Prerequisites

- Knowledge of Mathematics
- Fundamental knowledge of Computer

Syllabus

Unit 4 – Attributes of Output Primitives (8 hours)

- **Two-dimensional geometric transformations**
- **Basic transformations,**
- **Homogenous coordinate**
- **composite transformations**
- **Affine transformations,**
- **transformation functions, Roster methods for transformations.**

Recommended Books

Text books

- D. Hearn, P. Baker, "Computer Graphics - C Version", 2nd Edition, Pearson Education, 1997

Reference Book

- Heam Donald, Pauline Baker M: "Computer Graphics", PHI 2nd Edn. 1995.
- Harrington S: "Computer Graphics - A Programming Approach", 2nd Edn. Mc GrawHill.
- Shalini Govil-Pai, Principles of Computer Graphics, Springer, 2004

Additional online materials

- Coursera - https://www.coursera.org/learn/fundamentals-of-graphic-design
- https://www.youtube.com/watch?v=fwzYuhduME4&list=PLE4D97E3B8DB8A590
- NPTEL - https://nptel.ac.in/courses/106/106/106106090/
- https://www.coursera.org/learn/research-methods
- https://www.coursera.org/browse/physical-science-and-engineering/research-methods

Two-Dimensional Transformation

- Computer Graphics provide the facility of viewing object from different angles. The architect can study building from different angles i.e.
- Front Evaluation
- Side elevation
- Top plan
- A Cartographer can change the size of charts and topographical maps. So if graphics images are coded as numbers, the numbers can be stored in memory. These numbers are modified by mathematical operations called as Transformation.
- The purpose of using computers for drawing is to provide facility to user to view the object from different angles, enlarging or reducing the scale or shape of object called as Transformation.

Types of Transformations:

Translation

Scaling

Rotating

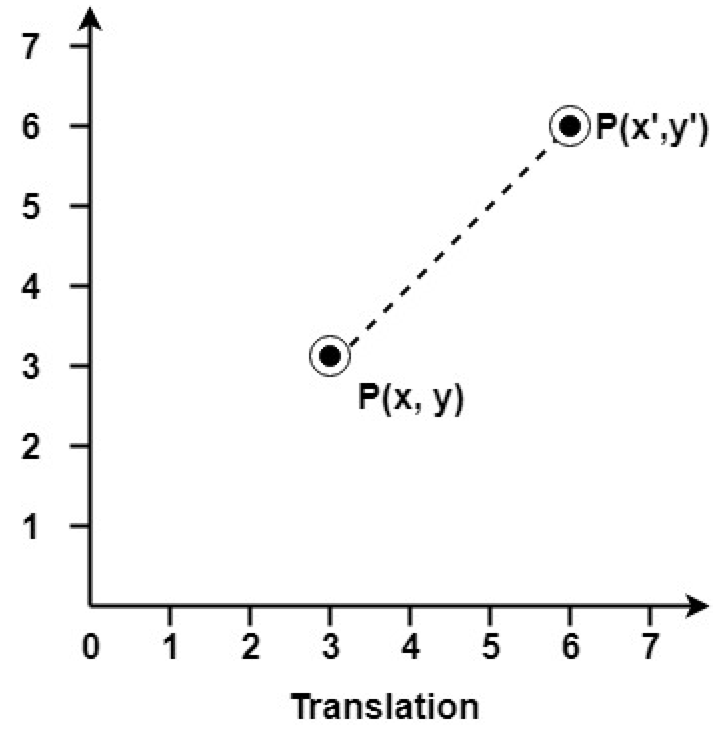
Reflection

Shearing

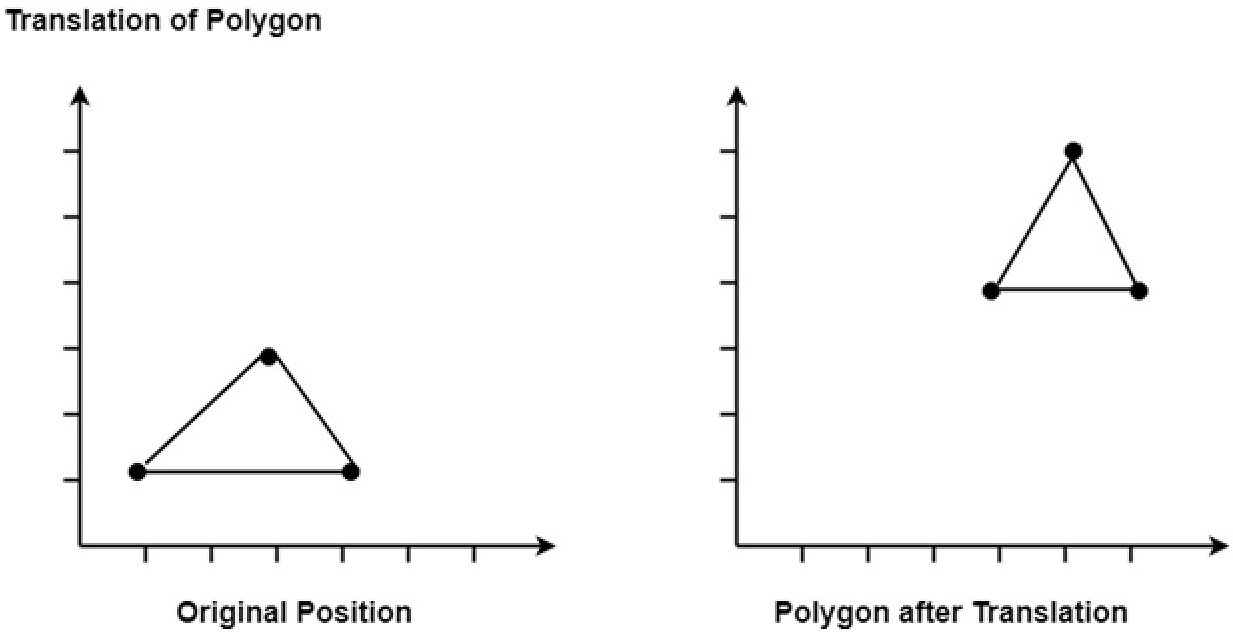
Translation

- Translation
- It is the straight line movement of an object from one position to another is called Translation. Here the object is positioned from one coordinate location to another.
- Translation of point:
- To translate a point from coordinate position (x, y) to another (x_1 y_1), we add algebraically the translation distances T_x and T_y to original coordinate.
- $x_1=x+T_x$ $y_1=y+T_y$
- The translation pair (T_x,T_y) is called as shift vector.
- Translation is a movement of objects without deformation. Every position or point is translated by the same amount. When the straight line is translated, then it will be drawn using endpoints.
- For translating polygon, each vertex of the polygon is converted to a new position. Similarly, curved objects are translated. To change the position of the circle or ellipse its center coordinates are transformed, then the object is drawn using new coordinates.

Area-Fill Attributes



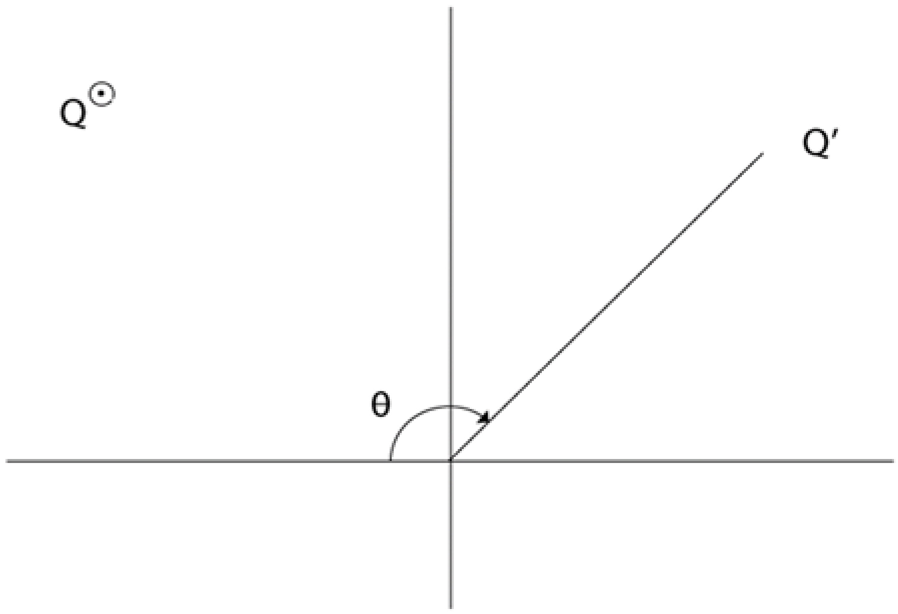
Translation



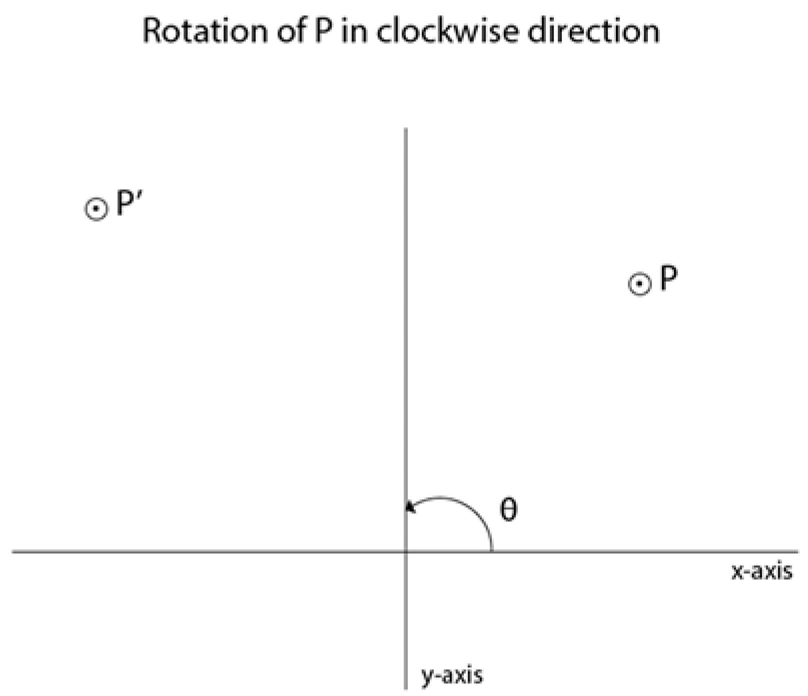
Rotation:

- It is a process of changing the angle of the object. Rotation can be clockwise or anticlockwise. For rotation, we have to specify the angle of rotation and rotation point. Rotation point is also called a pivot point. It is print about which object is rotated.
- Types of Rotation:
- Anticlockwise
- Counterclockwise

Rotation in anticlockwise direction



Q is original position
Q ' is final rotated position



P is original Position
P' is final position or position after rotation
where θ is angle of rotation

Rotation

Matrix for homogeneous co-ordinate rotation (anticlockwise)

$$R = \begin{pmatrix} \cos\theta & \sin\theta & 0 \\ -\sin\theta & \cos\theta & 0 \\ 0 & 0 & 1 \end{pmatrix}$$

- **Example1:** Prove that 2D rotations about the origin are commutative i.e. $R_1\ R_2=R_2\ R_1$.
- **Solution:** R_1 and R_2 are rotation matrices

$$R_1 = \begin{bmatrix} \cos\theta_1 & \sin\theta_1 & 0 \\ -\sin\theta_1 & \cos\theta_1 & 0 \\ 0 & 0 & 1 \end{bmatrix}$$

$$R_2 = \begin{bmatrix} \cos\theta_2 & \sin\theta_2 & 0 \\ -\sin\theta_2 & \cos\theta_2 & 0 \\ 0 & 0 & 1 \end{bmatrix}$$

$$R_1 * R_2 = \begin{bmatrix} \cos\theta_1 & \sin\theta_1 & 0 \\ -\sin\theta_1 & \cos\theta_1 & 0 \\ 0 & 0 & 1 \end{bmatrix} \begin{bmatrix} \cos\theta_2 & \sin\theta_2 & 0 \\ -\sin\theta_2 & \cos\theta_2 & 0 \\ 0 & 0 & 1 \end{bmatrix}$$

$$= \begin{bmatrix} \cos\theta_1 \cos\theta_2 - \sin\theta_1 \sin\theta_2 & \cos\theta_1\sin\theta_2 + \sin\theta_1\cos\theta_2 & 0 \\ -\sin\theta_1\cos\theta_2 - \cos\theta_1 \sin\theta_2 & -\sin\theta_1\sin\theta_2 + \cos\theta_1\cos\theta_2 & 0 \\ 0 & 0 & 1 \end{bmatrix} \ldots \text{eq 1}$$

$$R_2 * R_1 = \begin{bmatrix} \cos\theta_2 & \sin\theta_2 & 0 \\ -\sin\theta_2 & \cos\theta_2 & 0 \\ 0 & 0 & 1 \end{bmatrix} \begin{bmatrix} \cos\theta_1 & \sin\theta_1 & 0 \\ -\sin\theta_1 & \cos\theta_1 & 0 \\ 0 & 0 & 1 \end{bmatrix}$$

$$= \begin{bmatrix} \cos\theta_2 \cos\theta_1 - \sin\theta_2 \sin\theta_2 & \cos\theta_2\sin\theta_1 + \sin\theta_2\cos\theta_1 & 0 \\ -\sin\theta_2\cos\theta_1 - \cos\theta_2 \sin\theta_1 & -\sin\theta_2\sin\theta_2 + \cos\theta_2\cos\theta_1 & 0 \\ 0 & 0 & 1 \end{bmatrix} \ldots \text{eq 2}$$

From eq 1 & eq 2

$R_1R_2 = R_2R_1$. Hence Proved.

Questions

- **Example2:** Rotate a line CD whose endpoints are (3, 4) and (12, 15) about origin through a 45° anticlockwise direction.
- **Example3:** Rotate line AB whose endpoints are A (2, 5) and B (6, 12) about origin through a 30° clockwise direction.

Homogeneous Coordinates

- The rotation of a point, straight line or an entire image on the screen, about a point other than origin, is achieved by first moving the image until the point of rotation occupies the origin, then performing rotation, then finally moving the image to its original position.
- The moving of an image from one place to another in a straight line is called a translation. A translation may be done by adding or subtracting to each point, the amount, by which picture is required to be shifted.
- Translation of point by the change of coordinate cannot be combined with other transformation by using simple matrix application. Such a combination is essential if we wish to rotate an image about a point other than origin by translation, rotation again translation.
- To combine these three transformations into a single transformation, homogeneous coordinates are used. In homogeneous coordinate system, two-dimensional coordinate positions (x, y) are represented by triple-coordinates.

Thank You