

Projections & 3-D Clipping

By

Poonam Saini

Dept. of Computer Science & Engineering

Sir Padampat Singhanian University

Udaipur

Projections

Projections

- The output devices that we use are 2D devices and are not suitable for showing 3D objects. Therefore some operation has to be performed. This operation is called projection of the object.
- The problem of representing a 3D object or scene in 2D medium which is called the problem of projection.
- Projection can be defined as a mapping of a point $P(x,y,z)$ onto its image $P'(x',y',z')$ in the projection plane or view plane which constitutes the display surface.

Methods of Projection

- Perspective Projection
- Parallel Projection

Perspective Projection

- The technique of perspective projection are generalization of the principles used by the artists in preparing perspective drawing of 3D objects and scenes.
- The eye of the artists is placed as at the center of projection/canvas/plane containing the canvas becomes the view plane.
- An image point is determined by a projector that goes from an object point to the center of projection.

Perspective Anomalies

- **Perspective foreshortening:** The farther an object is from the center of projection the smaller it appears.
- **Vanishing points:** Projections of line that are not parallel to the view plane appear to meet at the same point on the view plane. Eg. Rail road track.
- **View confusion:** Objects behind the center of projection are projected upside down and backward onto the view plane.

Parallel Projection

- The parallel projection methods are used by drafters and engineers to create working drawings of an object which preserves its scale and shape.
- The complete representation of these details often require two or more views of the objects onto different view planes.
- In parallel projection, image points are found as the intersection of the view plane with a projector drawn from the object point and having a fixed direction.

Orthographic Projection

- These are characterized by the fact that the direction of projection is perpendicular to the view plane when the direction of projection is parallel to any of the principle axes, this produces the front, top and side views of mechanical drawings.

Axometric Projection

- These are orthographic projections in which the direction of projection is not parallel to any of the three axes.

Oblique parallel Projection

- Non orthographic projections are called oblique parallel projections.

Subcategories of Orthographic Projections

- **Isometric:** The direction of projection makes equal angles with one principle axes.
- **Dimetric:** The direction of projection makes equal angles with exactly two of the principle axes.
- **Trimetric:** The direction of projection makes unequal angles with all the three principle axes.

Subcategories of Oblique Projections

- **Cavalier:** The direction of projection is chosen so that there is no foreshortening of lines perpendicular to xy plane.
- **Cabinet:** The direction of projection is chosen so that lines perpendicular to the xy planes are foreshortened by half their lengths.

3-D Clipping

- In 2-D clipping, we consider a window as a clipping boundary while in 3-D we consider the view volume.
- View volume is a box between the two planes i.e. front plane and back plane.
- The part of the object which lies inside the view volume will be displayed and the part which lies outside will be clipped.
- For a parallel projection a box or region is a rectangular area and in perspective projection it is truncated pyramidal volume also known as frustum of vision.

3-D Clipping

- **View volume** has six sides : Left, Right, Top, Bottom, Hither and Yon.
- In 3-D clipping we compare the point against the plane to find whether it is inside the visible region or not.

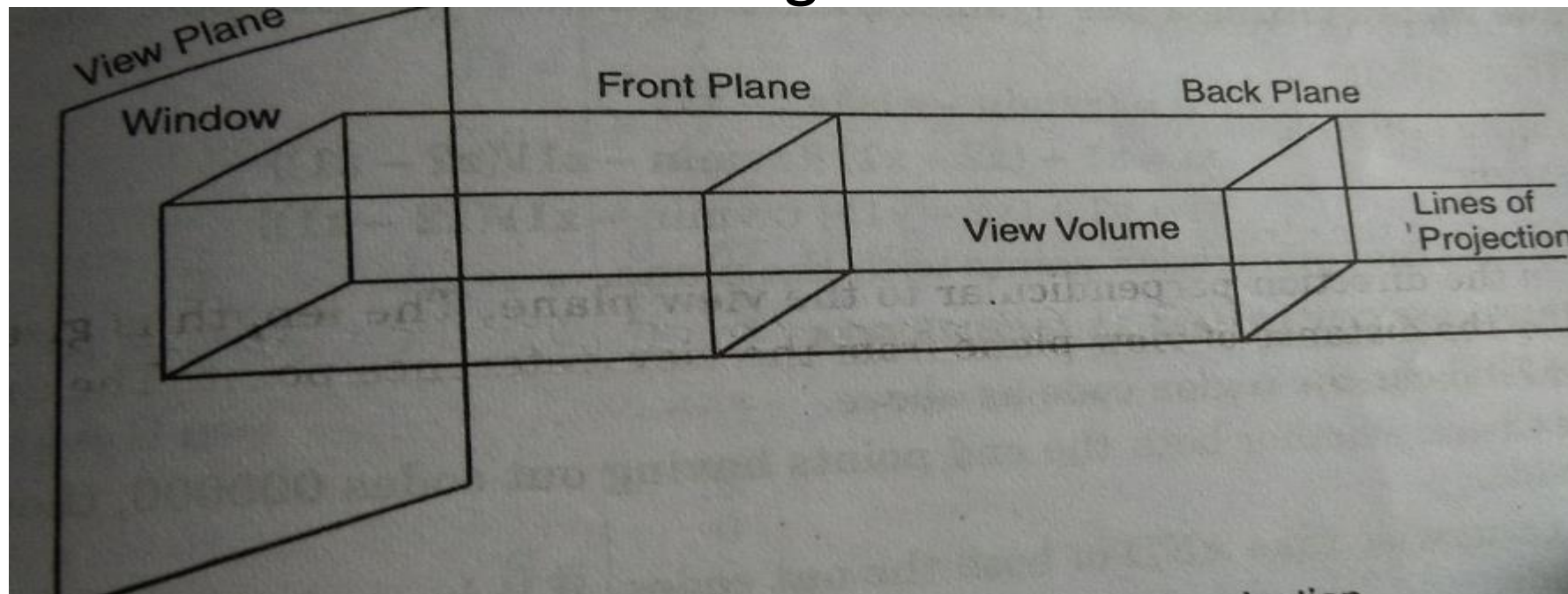


Fig.: View Volume for Parallel Projection

3-D Clipping

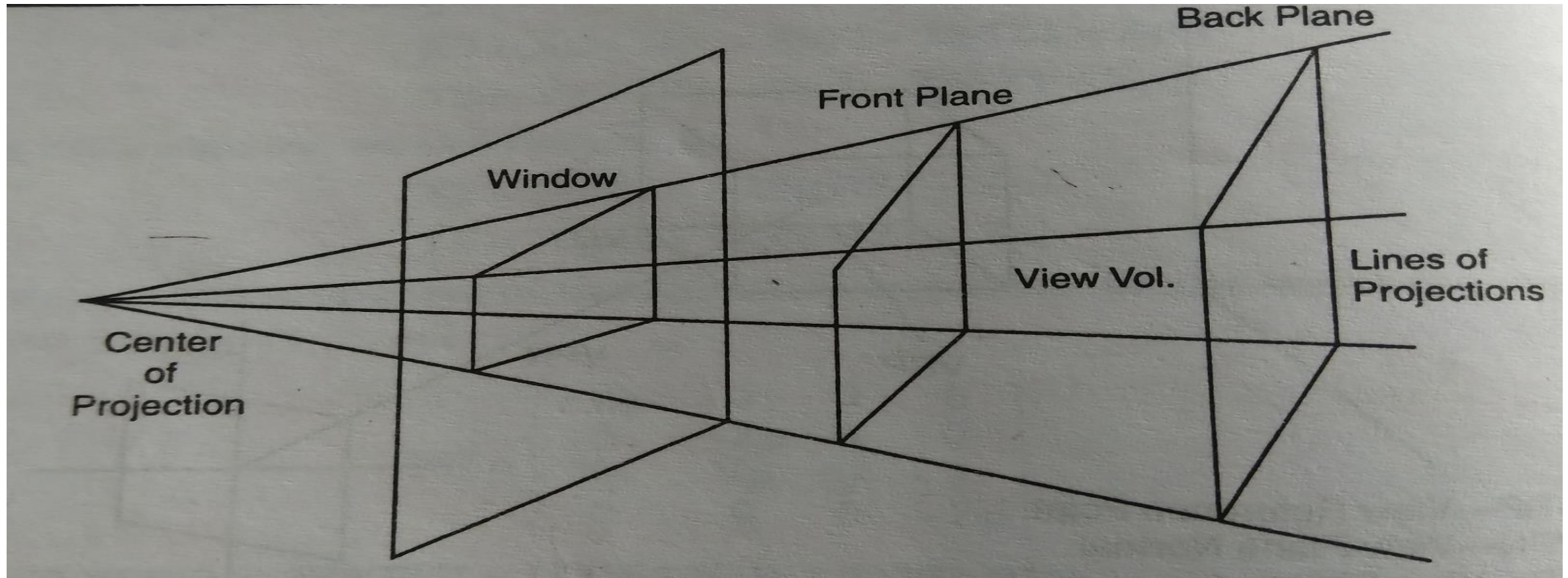


Fig.: View Volume for Perspective Projection

3-D Clipping

- The front and back planes will be positioned relative to the view reference point in the direction of the view plane normal.
- For extension of Cohen-Sutherland line clipping method in three dimension, we use 6 bits. The bits are set 1 for the following conditions:

Bit 1 =1 if $x < x_{vmin}$

Bit 1 =1 if $x > x_{vmax}$

Bit 1 =1 if $y < y_{vmin}$

Bit 1 =1 if $y > y_{vmax}$

Bit 1 =1 if $z < z_{vmin}$

Bit 1 =1 if $z > z_{vmax}$

3-D Clipping

- If both the end points having region codes 000000 then the lines are visible.
- If end point codes has 1 in same bit, the line is completely outside and it can be rejected.
- Otherwise, find the intersection points.

3-D Clipping

Mid Point subdivision algorithm

Step 1: Find the region codes

Step 2: Check whether both the end points having region codes 000000, then the line is completely inside.

Step 3. Otherwise take AND of both the region codes, if at the same bit position of both the end points having value 1 then line is completely outside and can be rejected.

Step 4: Otherwise find out the midpoint of a line using

$$x_m = (x_1 + x_2) / 2$$

$$y_m = (y_1 + y_2) / 2$$

$$z_m = (z_1 + z_2) / 2$$

Step 5: Repeat steps 1 to 3 until line is completely inside or outside.