CS 461 - Computer Graphics

Hierarchical Modeling

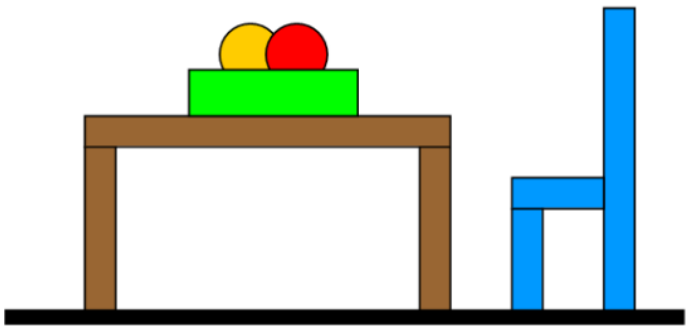
Concept

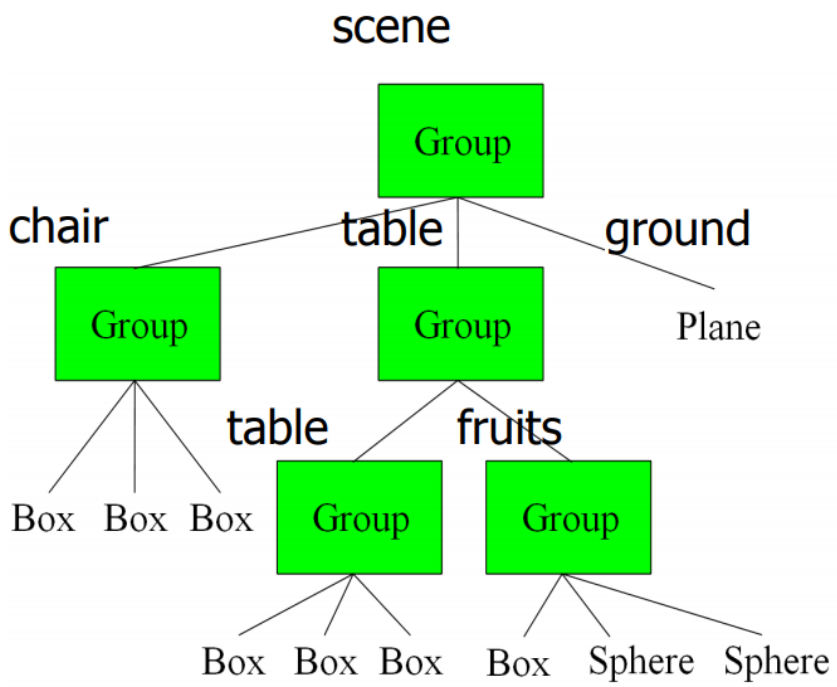
- Triangles, parametric curves and surfaces are the building blocks from which more complex real-world objects are modeled
- Hierarchical modeling creates complex real-world objects by combining simple primitive shapes into more complex aggregate objects

Concept

Scene Graph

- The “scene graph” represents the logical organization of scene
- Data structure for intuitive construction of 3D scenes

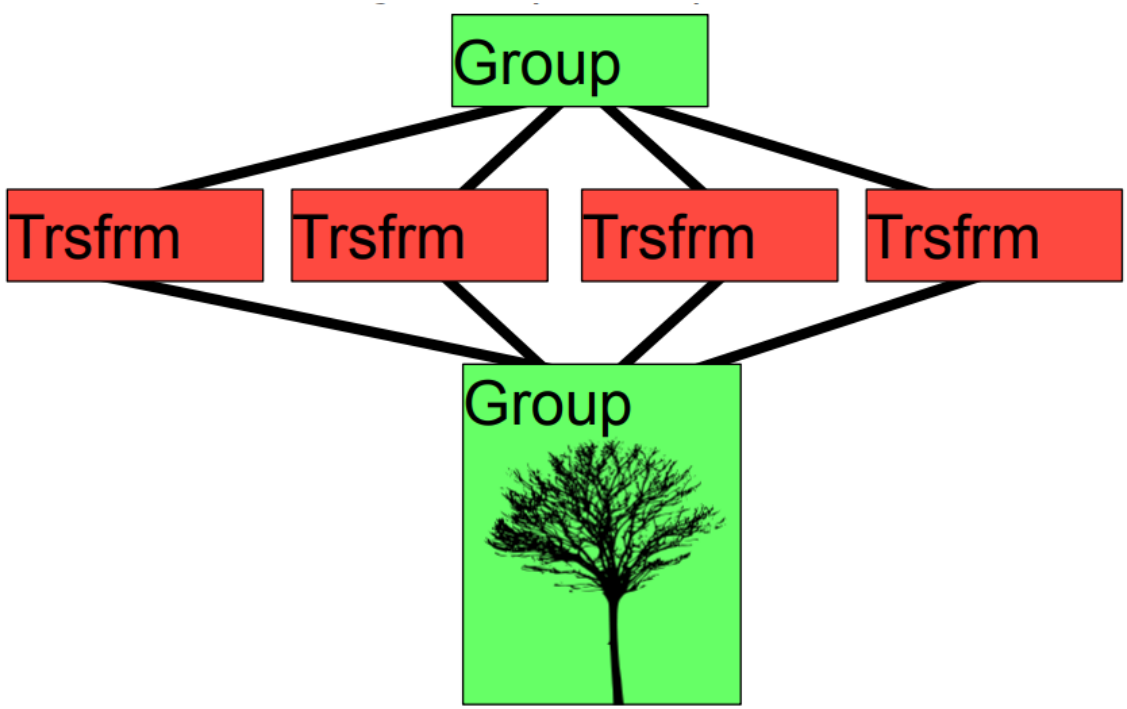




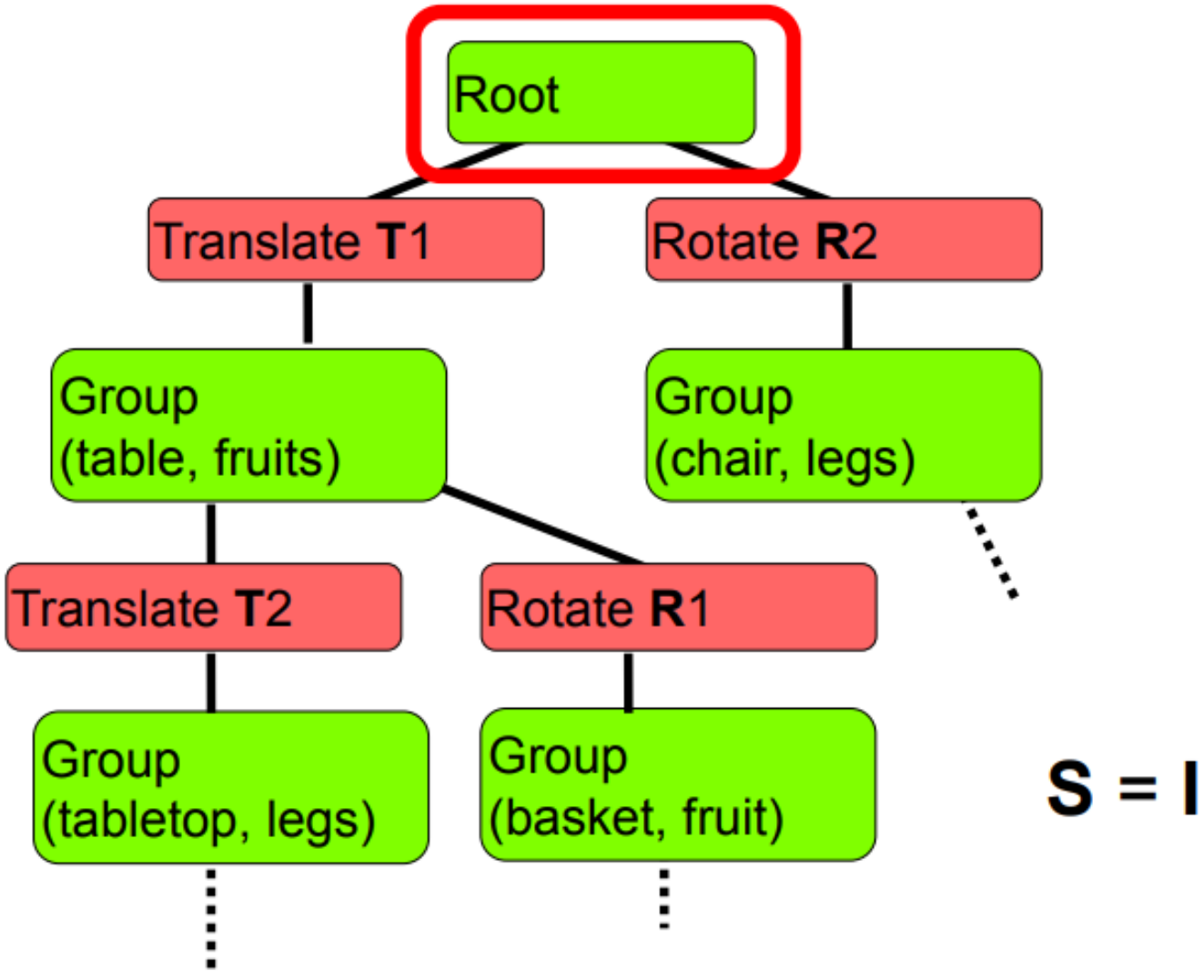
Scene Graph

- Convenient data structure
- Basic idea: Hierarchical tree
- Useful for manipulation/animation
- Useful for rendering

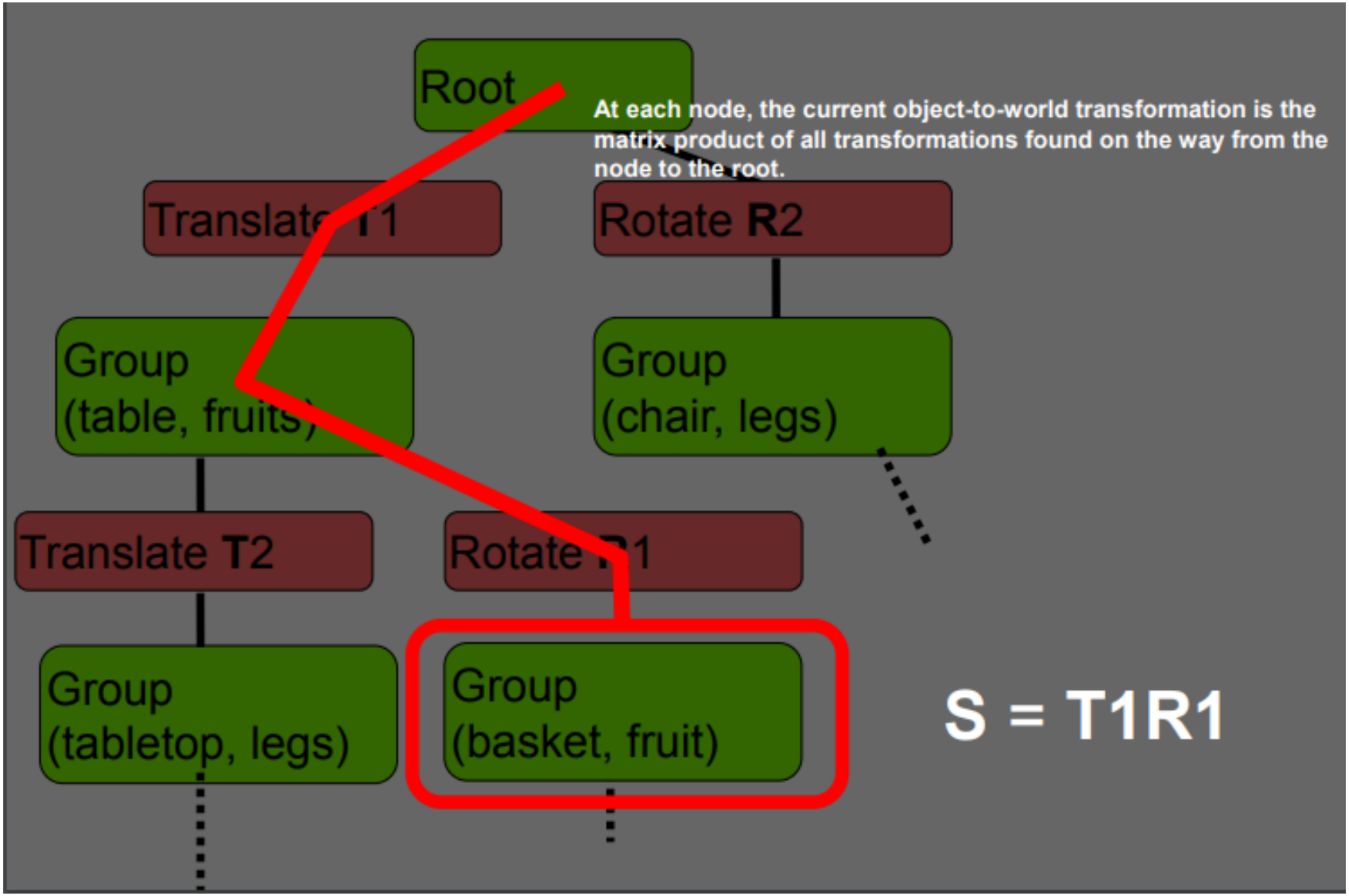
Scene Graph



Scene graph traversal

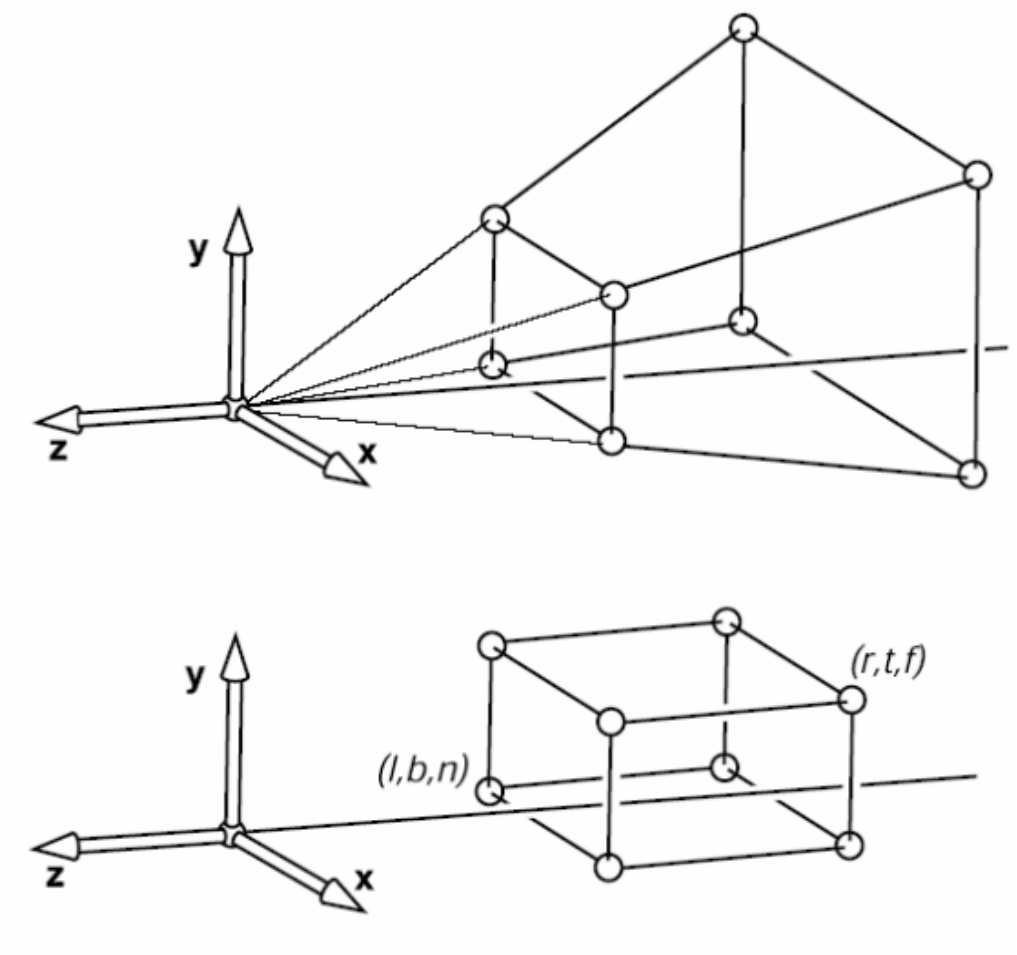


Scene graph traversal



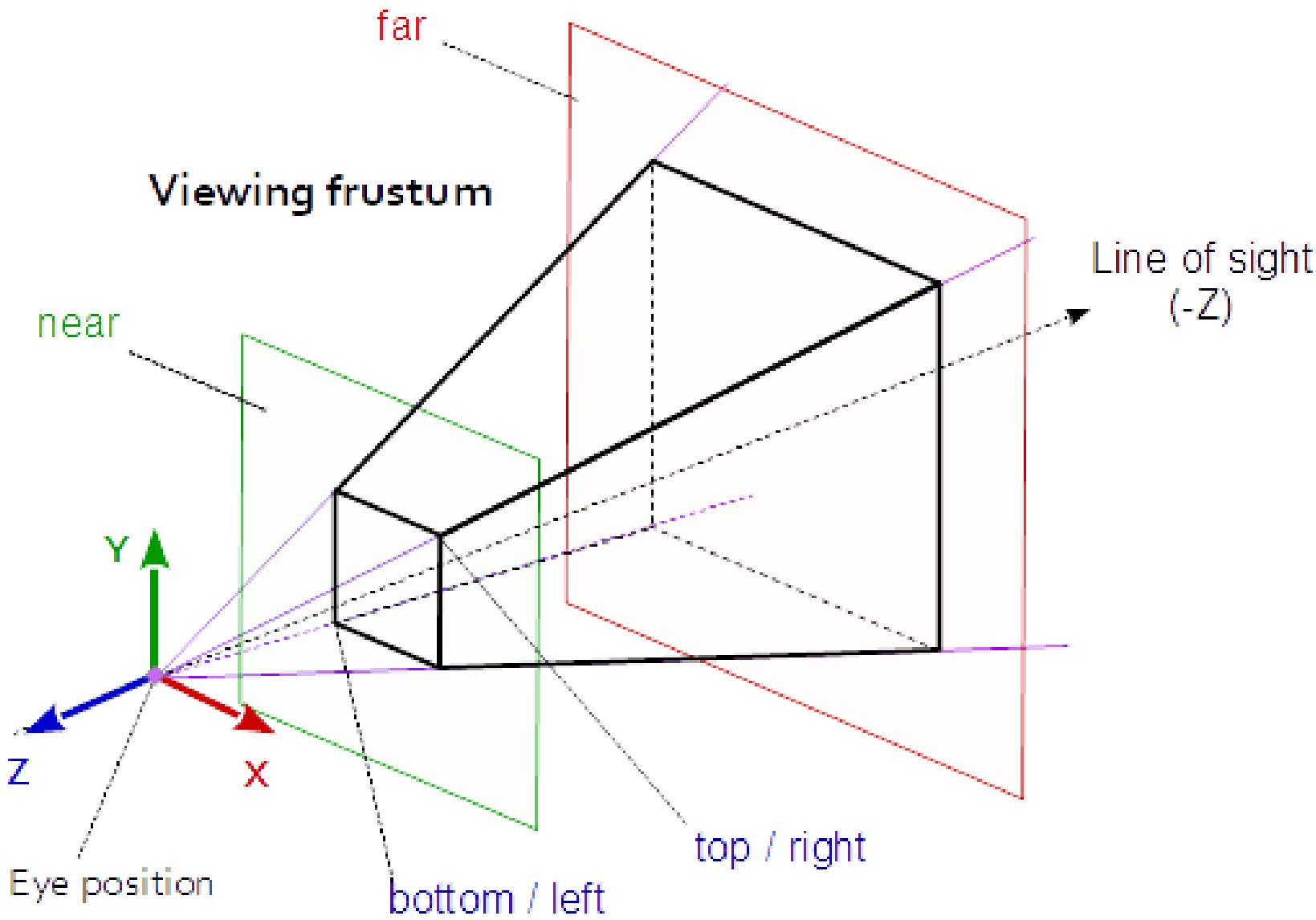
Camera Transformation

Parallel and Perspective projections

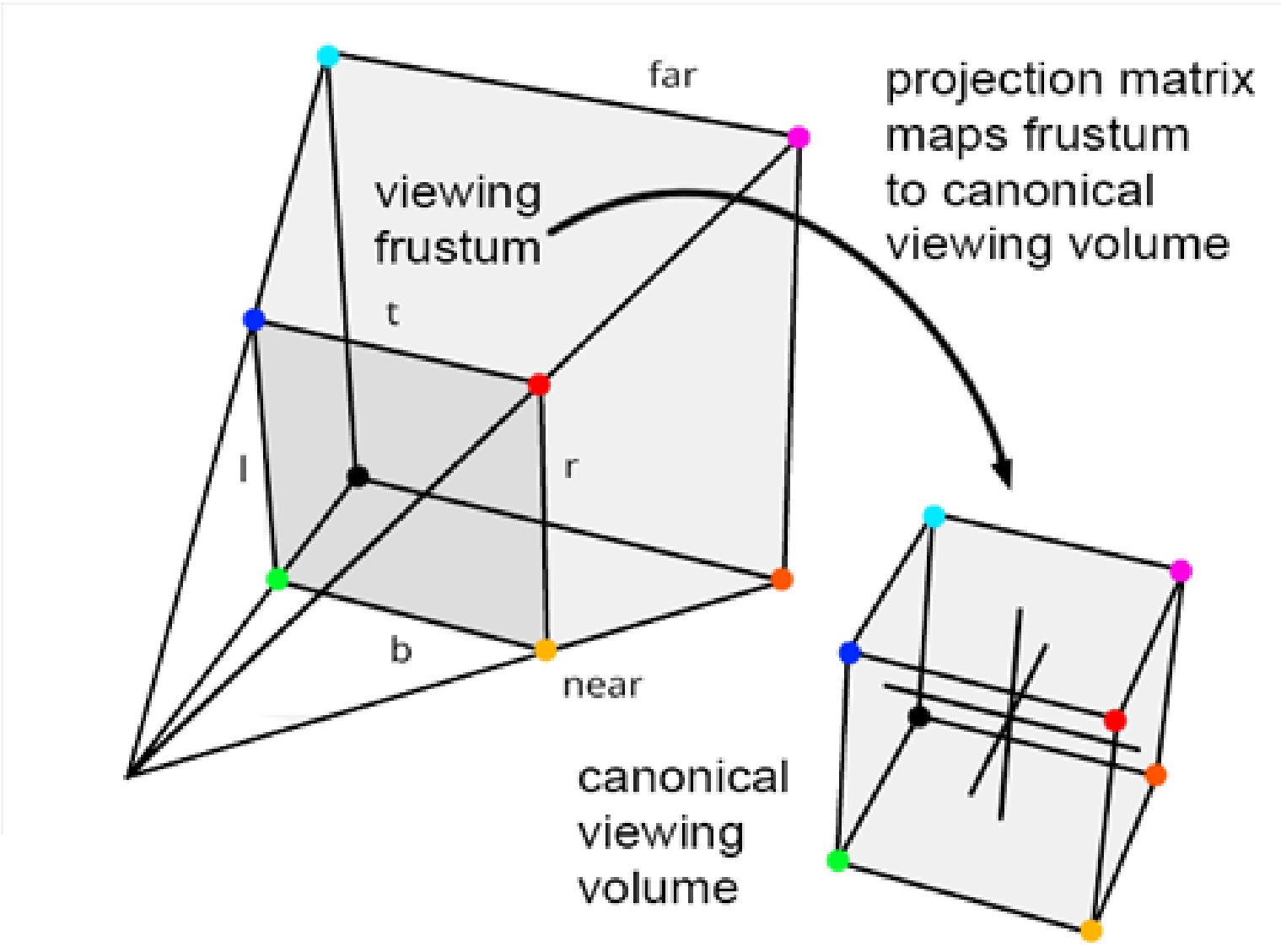


Vanishing points

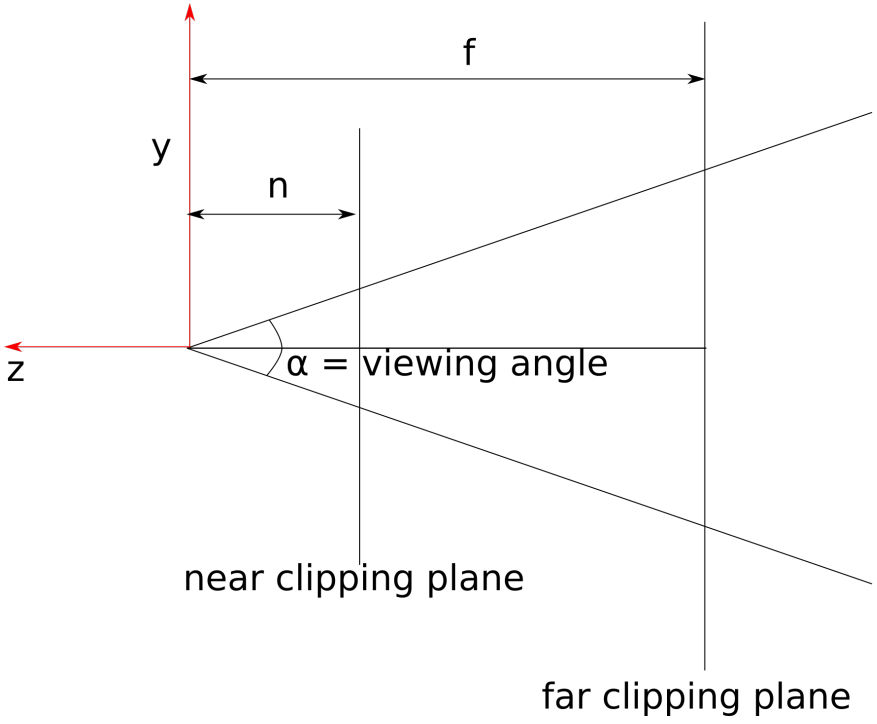
Viewing frustum

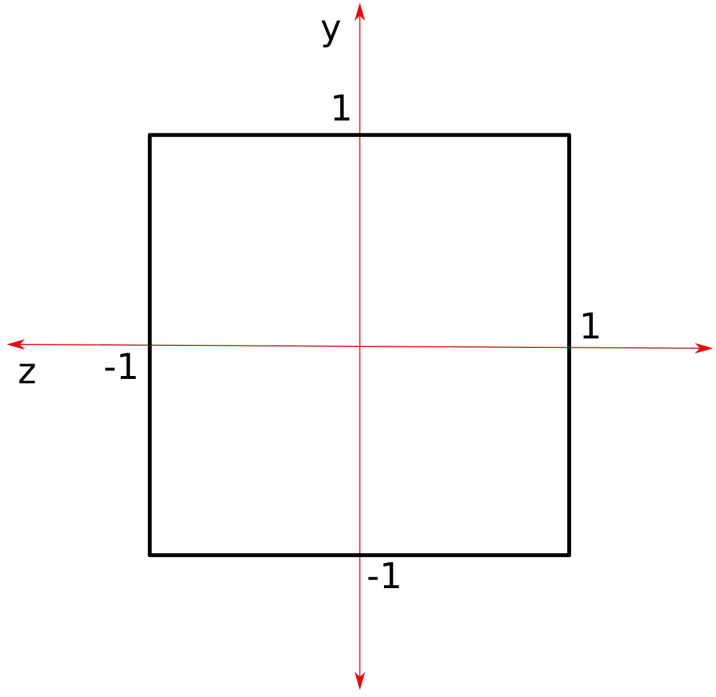


Frustum to cube



Basic Idea


f
y
n
z
α = viewing angle
near clipping plane
far clipping plane


y
1
1
z
-1
-1

Transformation Matrix

$$\begin{bmatrix} x & y & z & 1 \end{bmatrix} * \begin{bmatrix} 1 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 \\ 0 & 0 & a & -1 \\ 0 & 0 & b & 0 \end{bmatrix} = \begin{bmatrix} x & y & az+b & -1 \end{bmatrix}$$

- Let the matrix be V, we know that:

$$\begin{bmatrix} 0 & 0 & -n & 1 \end{bmatrix} * V = \begin{bmatrix} 0 & 0 & -an+b & n \end{bmatrix}$$

$$\begin{bmatrix} 0 & 0 & -f & 1 \end{bmatrix} * V = \begin{bmatrix} 0 & 0 & -af+b & f \end{bmatrix}$$

Transformation Matrix

- Going back to 3D:

$$\begin{bmatrix} 0 & 0 & -an+b & n \end{bmatrix} \longrightarrow \begin{bmatrix} 0 & 0 & \frac{-an+b}{n} \end{bmatrix} = \begin{bmatrix} 0 & 0 & 1 \end{bmatrix}$$

$$\begin{bmatrix} 0 & 0 & -af+b & f \end{bmatrix} \longrightarrow \begin{bmatrix} 0 & 0 & \frac{-af+b}{f} \end{bmatrix} = \begin{bmatrix} 0 & 0 & -1 \end{bmatrix}$$

- -an+b=n
- -af+b=-f
- $a = \frac{f+n}{f-n}$
- $b = \frac{2nf}{f-n}$

Transformation matrix

$$V = \begin{bmatrix} 1 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 \\ 0 & 0 & (f+n)/(f-n) & -1 \\ 0 & 0 & (2nf)/(f-n) & 0 \end{bmatrix}$$

- Take the top-most point in the near clipping plane

$$\begin{bmatrix} 0 & n * tan(\alpha/2) & -n & 1 \end{bmatrix} \longrightarrow \begin{bmatrix} 0 & 1 & 1 \end{bmatrix}$$

$$V = \begin{bmatrix} cot(\alpha/2) & 0 & 0 & 0 \\ 0 & cot(\alpha/2) & 0 & 0 \\ 0 & 0 & (f+n)/(f-n) & -1 \\ 0 & 0 & (2nf)/(f-n) & 0 \end{bmatrix}$$

Next class

- October 19^{th} 9 - 10
- Project submission deadline till today evening (4 p.m.) - no emails - directly fill the sheets
- Reminder for project presentation slots