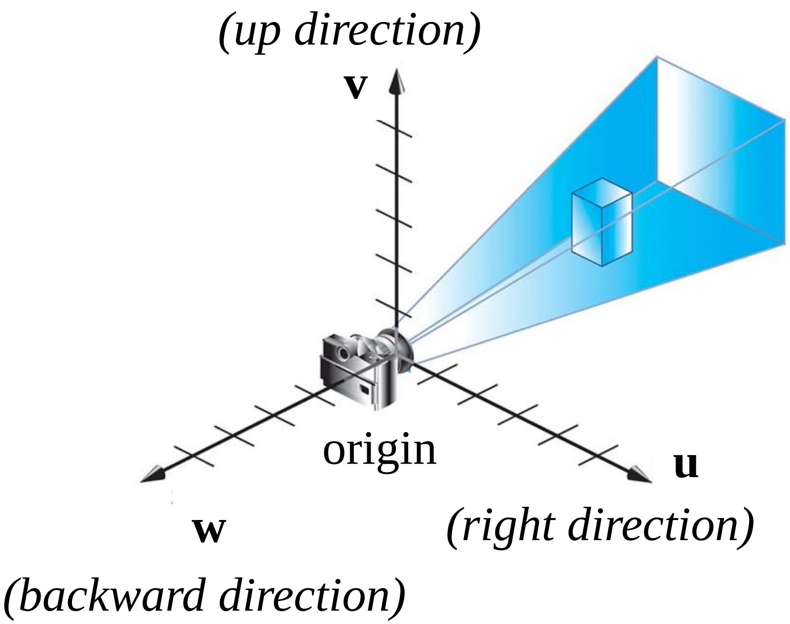
Defining Camera’s Coordinate System

- From the given **eye point**, **look-at point**, **up vector**, we can compute the camera frame.

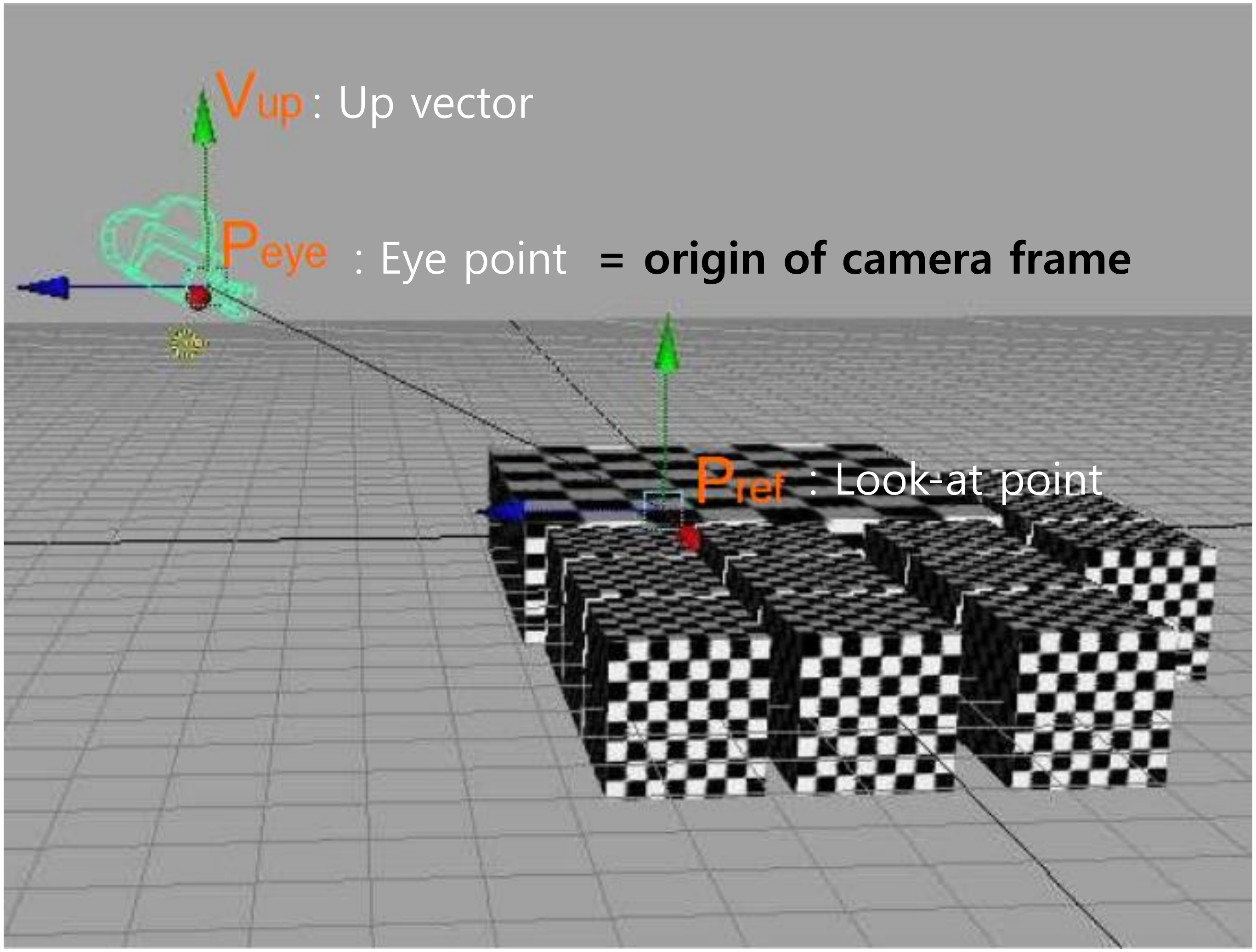
- **u, v, w** are commonly used for camera coordinates axes instead of x, y, z.



- What we have to do to define the coordinate system:

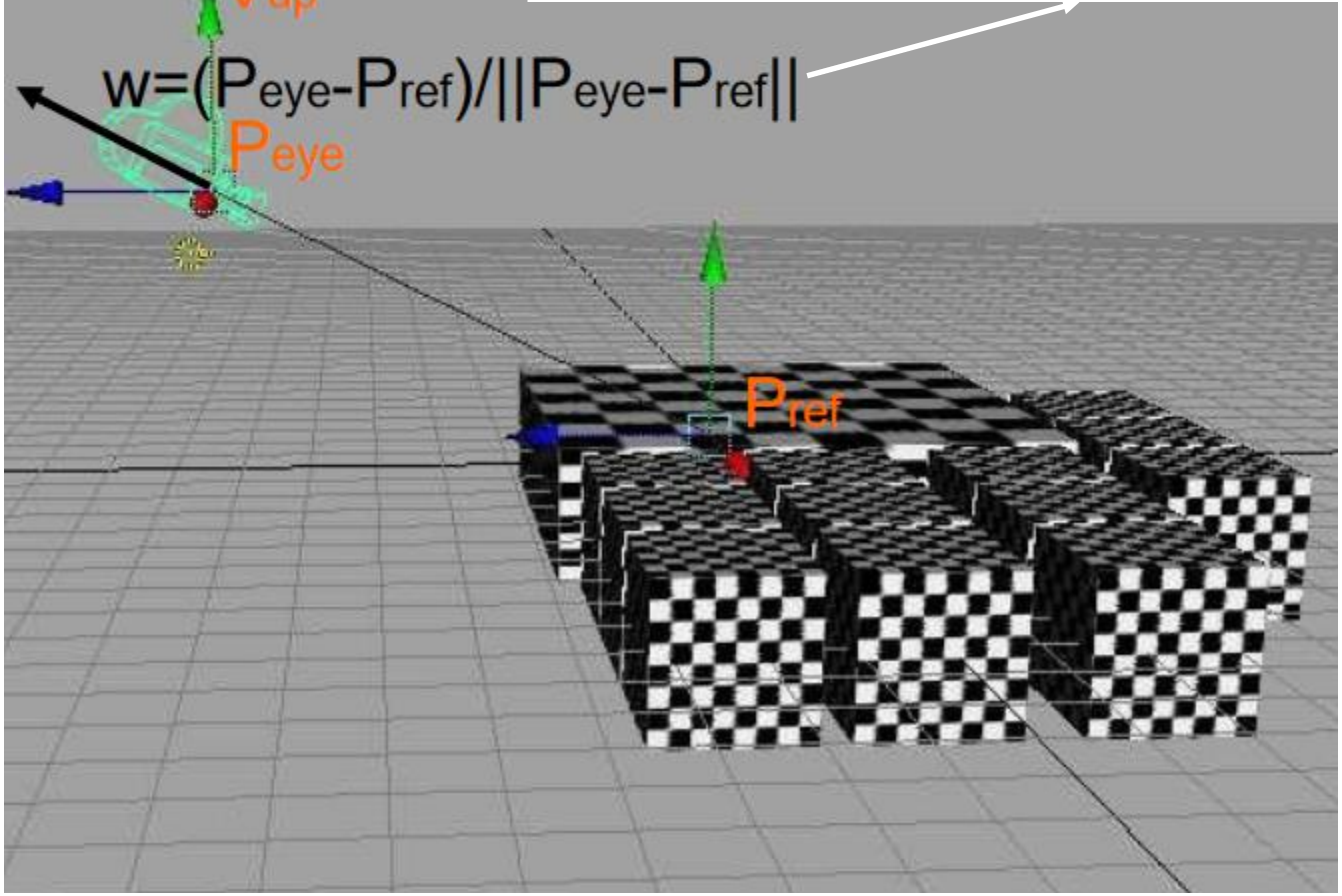
- Finding **u, v, w** vectors
- Finding the **origin** point
- (expressed in global frame)

Given Eye point, Look-at point, Up vector,

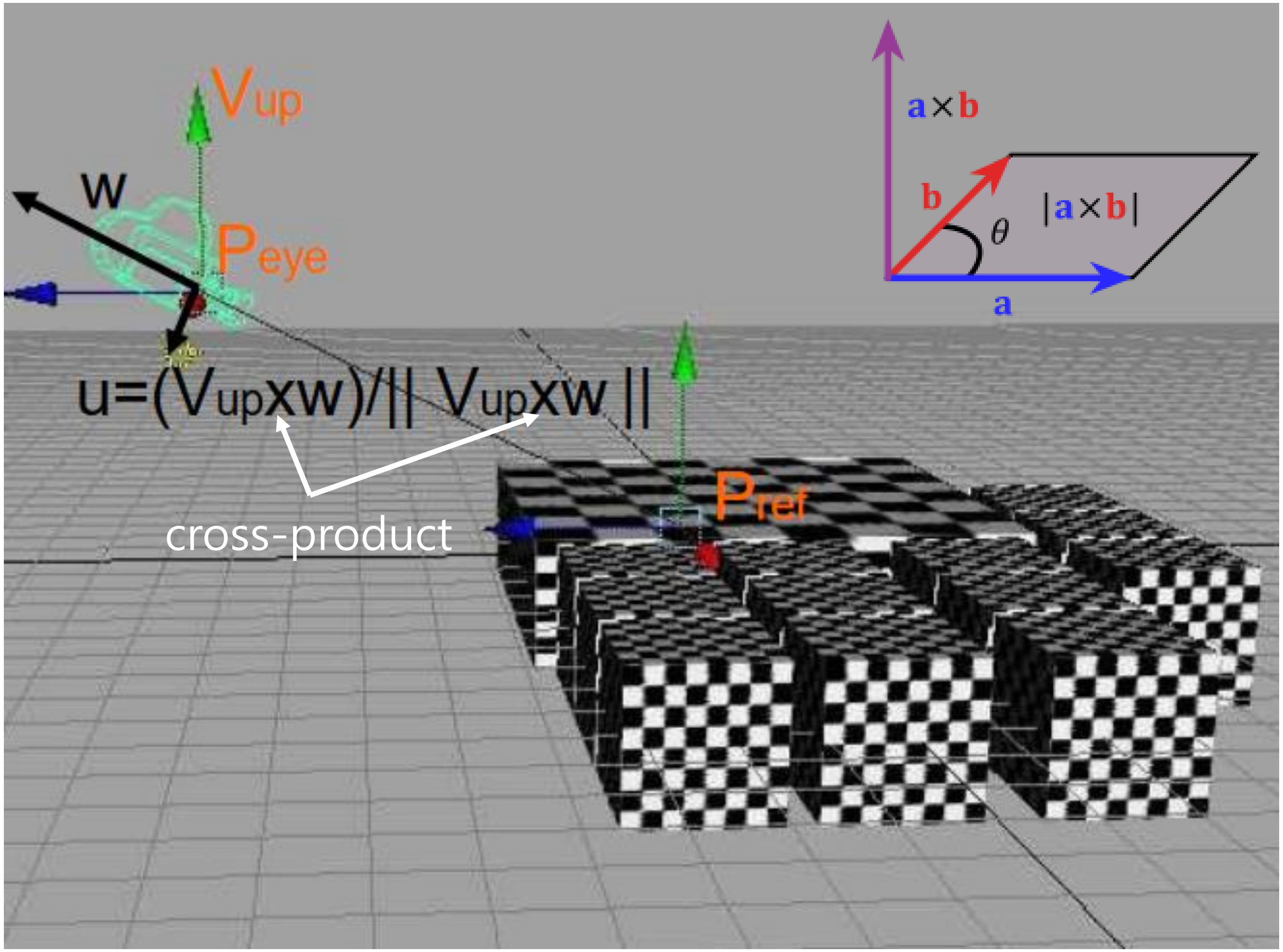


Getting “w” axis vector

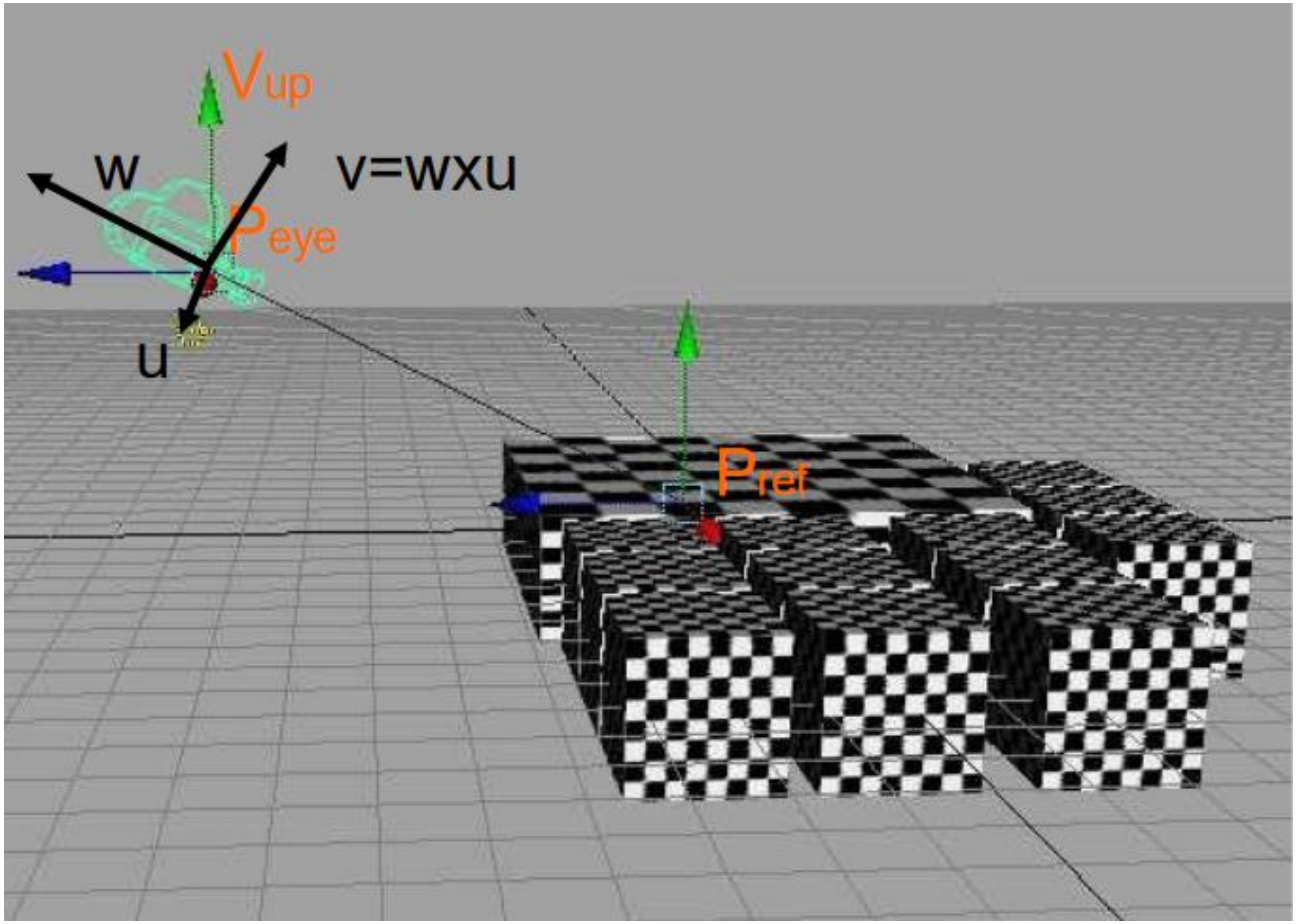
magnitude(l2 norm) of a vector: $|\mathbf{x}| = \sqrt{x_1^2 + x_2^2 + x_3^2}$.



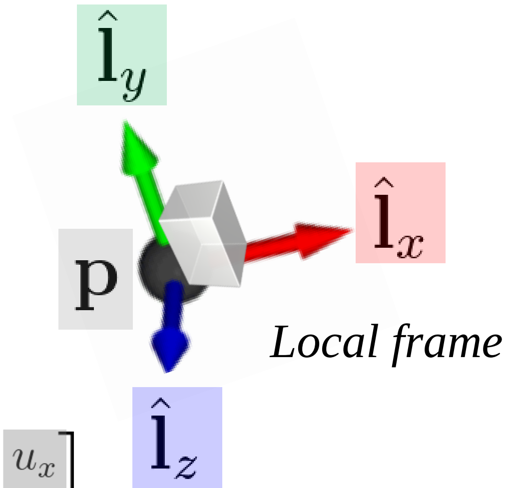
Getting “u” axis vector

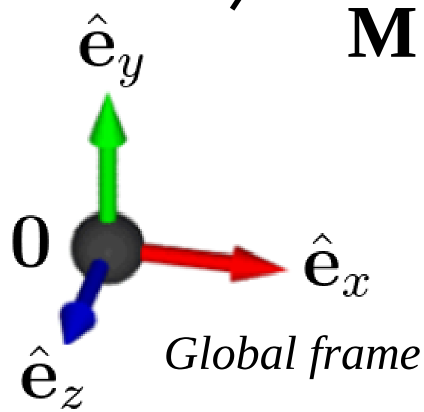


Getting “v” axis vector



2) A 4x4 Affine Transformation Matrix defines an Affine Frame w.r.t. Global Frame





$$\mathbf{M} = \begin{bmatrix} m_{11} & m_{12} & m_{13} & u_x \\ m_{21} & m_{22} & m_{23} & u_y \\ m_{31} & m_{32} & m_{33} & u_z \\ 0 & 0 & 0 & 1 \end{bmatrix}$$

x axis *vector*

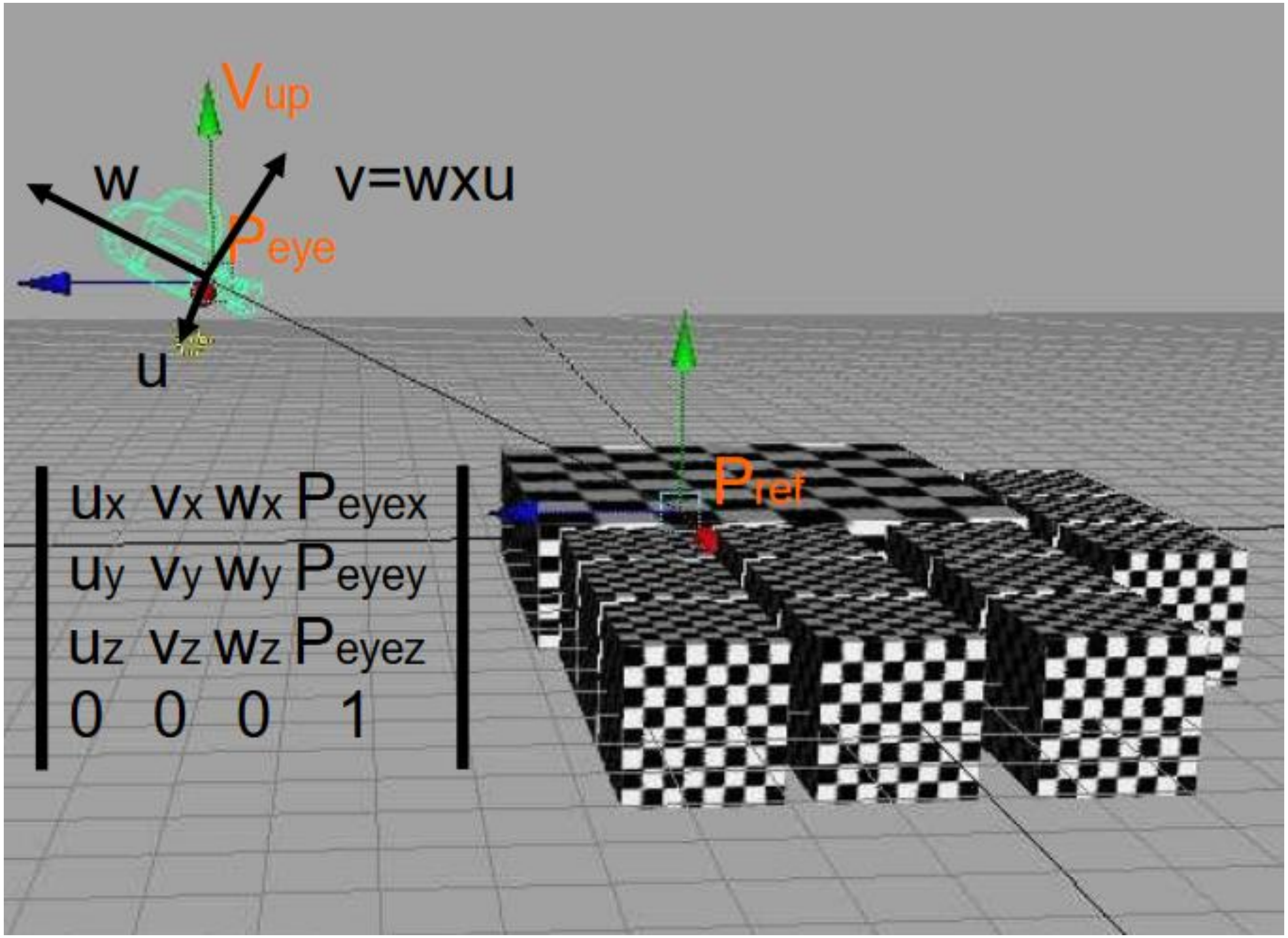
y axis *vector*

z axis *vector*

origin *point*

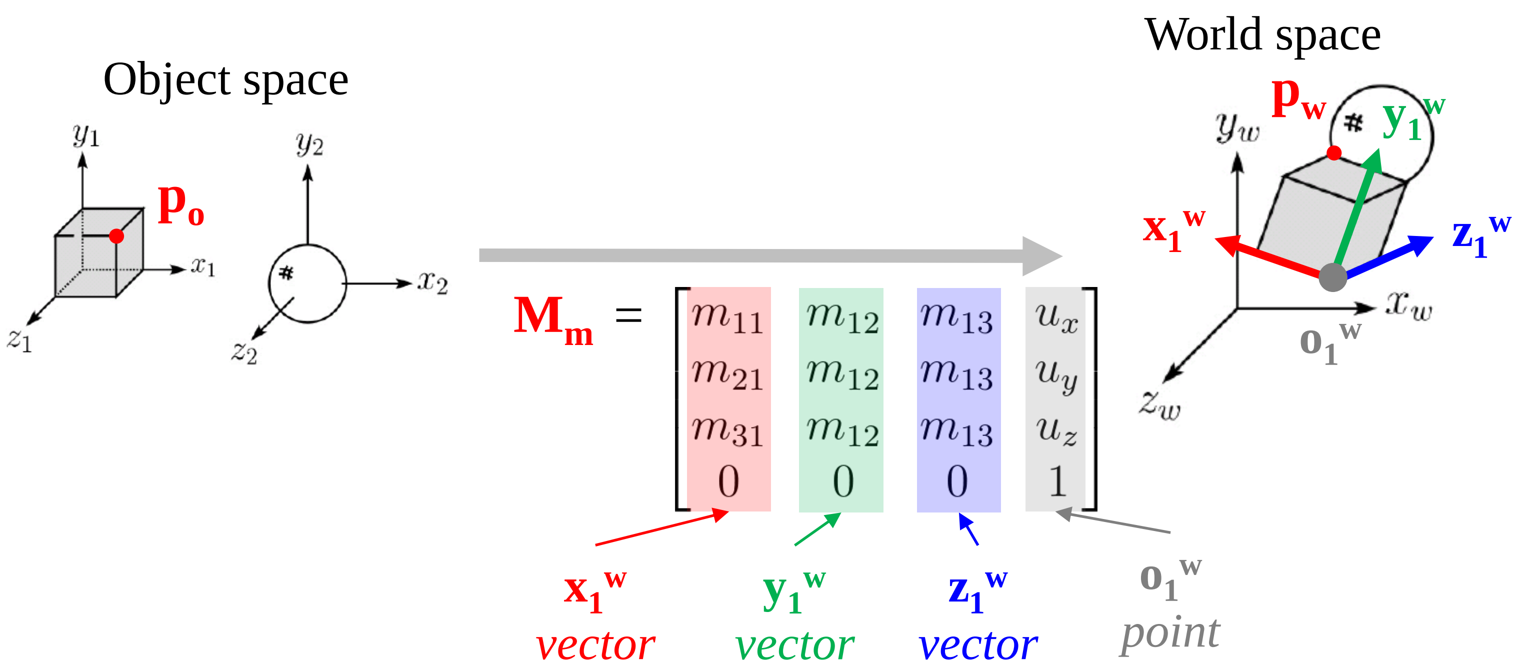
: The axis vectors and origin point of the **object's local frame represented in the global frame**

Thus, the Camera Frame is defined by



How can we get viewing matrix M_v from this camera frame?

- Recall the modeling transformation:



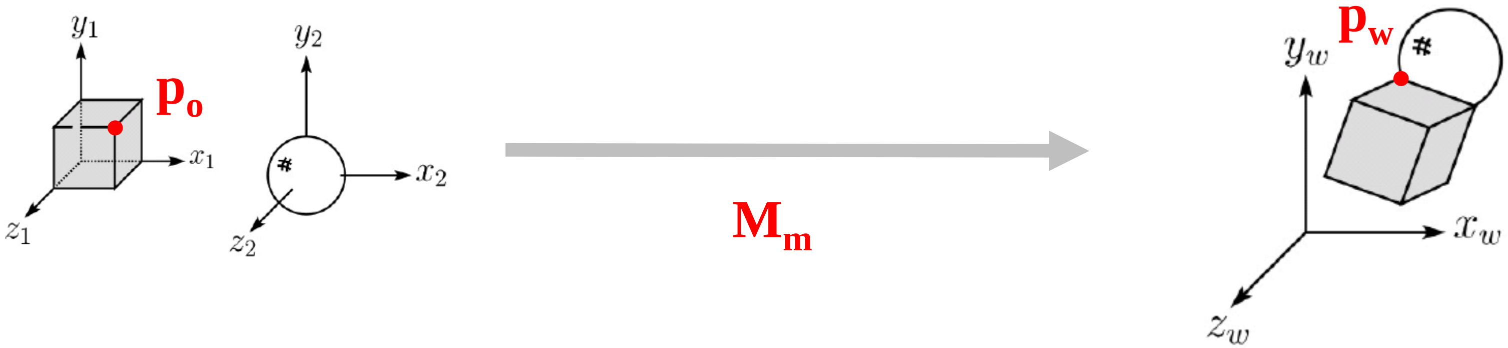
$$\mathbf{M_m} = \begin{bmatrix} m_{11} & m_{12} & m_{13} & u_x \\ m_{21} & m_{12} & m_{13} & u_y \\ m_{31} & m_{12} & m_{13} & u_z \\ 0 & 0 & 0 & 1 \end{bmatrix}$$

: The axis vectors and origin point of the **object's local frame represented in the global frame**

How can we get viewing matrix M_v from the camera frame?

- If we replace *object space* to *camera space*, what should be the transformation matrix?

Object space

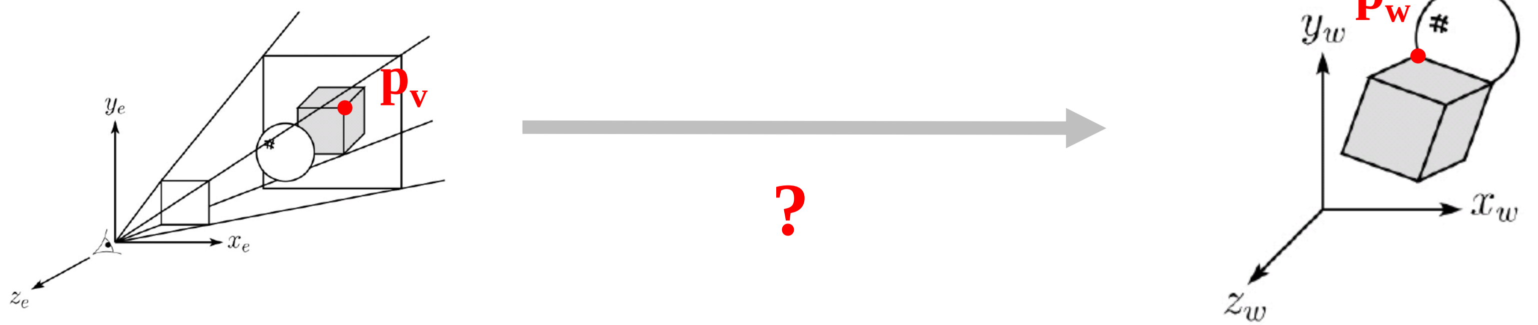


World space

How can we get viewing matrix M_v from the camera frame?

- If we replace *object space* to *camera space*, what should be the transformation matrix?

View space
(Camera space)

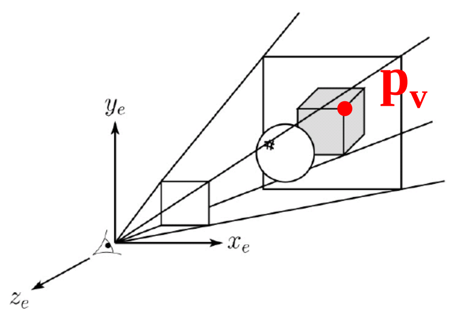


World space

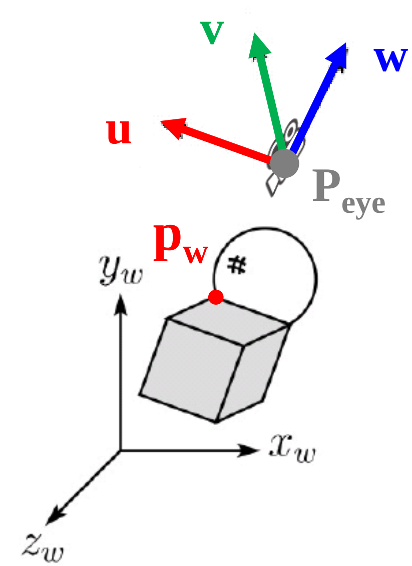
How can we get viewing matrix M_v from the camera frame?

- If we replace *object space* to *camera space*, what should be the transformation matrix?

View space
(Camera space)



$$\begin{bmatrix} u_x & v_x & w_x & P_{eyex} \\ u_y & v_y & w_y & P_{eyey} \\ u_z & v_z & w_z & P_{eyez} \\ 0 & 0 & 0 & 1 \end{bmatrix}$$

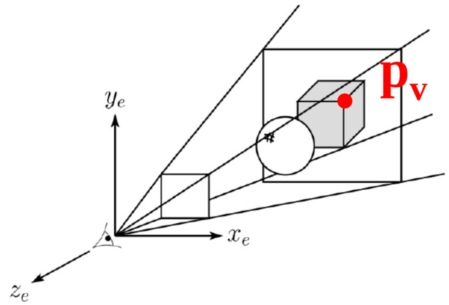


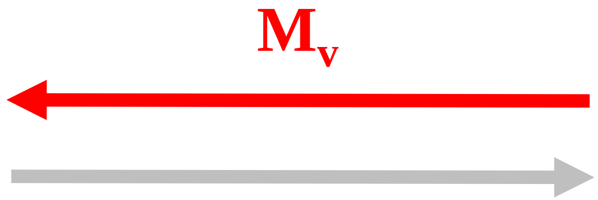
World space

: The axis vectors and origin point of the **camera frame represented in the global frame**

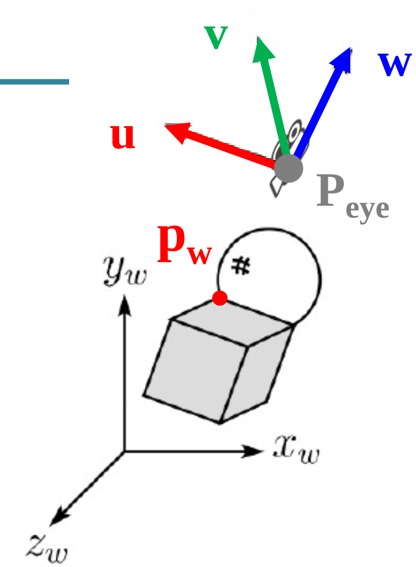
Viewing Transformation is the Opposite Direction

View space
(Camera space)





$$\begin{vmatrix} u_x & v_x & w_x & P_{eyex} \\ u_y & v_y & w_y & P_{eyey} \\ u_z & v_z & w_z & P_{eyez} \\ 0 & 0 & 0 & 1 \end{vmatrix}$$



World space

$$\mathbf{M_v} = \begin{vmatrix} u_x & v_x & w_x & P_{eyex} \\ u_y & v_y & w_y & P_{eyey} \\ u_z & v_z & w_z & P_{eyez} \\ 0 & 0 & 0 & 1 \end{vmatrix}^{-1} = \begin{bmatrix} u_x & u_y & u_z & -\mathbf{u}\cdot\mathbf{p}_{eye} \\ v_x & v_y & v_z & -\mathbf{v}\cdot\mathbf{p}_{eye} \\ w_x & w_y & w_z & -\mathbf{w}\cdot\mathbf{p}_{eye} \\ 0 & 0 & 0 & 1 \end{bmatrix}$$

Acknowledgement

- Acknowledgement: Some materials come from the lecture slides of
  - Prof. Karan Singh http://www.dgp.toronto.edu/~karan/courses/418/