

# CIS 580, Machine Perception, Spring 2021

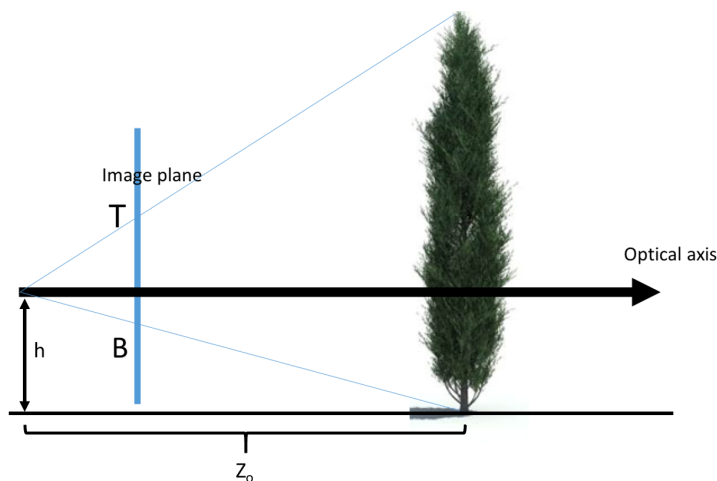
## Homework 1 due Thursday February 4, 2021, at 11:59pm

### Instructions

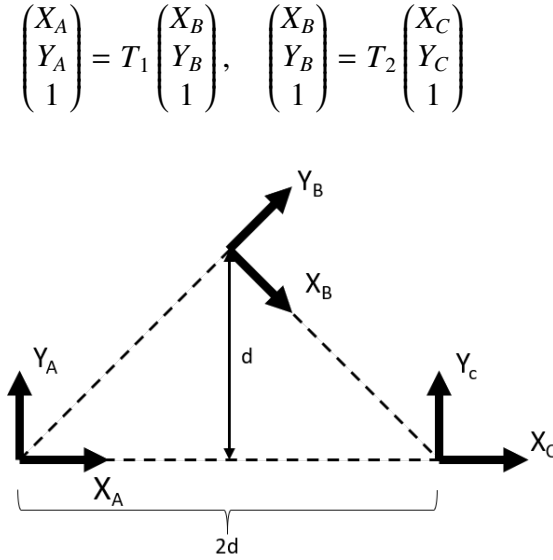
- This is a homework you have to solve by yourself.
- You must submit your solutions on [Gradescope](#). We recommend that you use  $\text{\LaTeX}$ , but we will accept scanned solutions as well.
- Start early! If you get stuck, please post your questions on [Piazza](#) or come to office hours!

### Homework

1. Assume that you see the bottom and the top of a vertical tree in front of you. The optical axis is parallel to the ground and the height of the projection center with respect to the ground is  $h$ . The image plane is vertical as well and you see the bottom and the top of the tree at calibrated ( $K = I$ ) coordinates  $B = (0, y_1)$  and  $T = (0, y_2)$ , respectively. Compute the horizontal distance  $Z_0$  between the projection center and the tree. (Compute the result with respect to  $h, y_1, y_2$ . It is not required that all of them appear in the result)



2. Assume the same configuration as Question 1, but while we keep the projection center at the same position we double the distance between the image plane and projection center.
- (a) What are the new coordinates  $B'$ ,  $T'$  for the projections of the bottom and the top of the tree at the image plane?
- (b) How much would we have to move the projection center so that the bottom and the top of the tree appear at the original coordinates  $B = (0, y_1)$ ,  $T = (0, y_2)$  in the image plane? (We assume that while we move the projection center we keep the distance between the projection center and the image plane constant)
3. Find the transformations  $T_1, T_2$  given the configuration from the figure below:

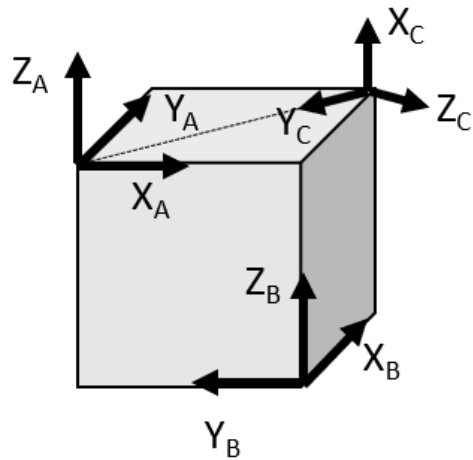


Note:  $\cos(\pi/4)$ ,  $\sin(\pi/4)$  can appear in the solution. You should not replace them with their numerical value. You have to multiply out the matrices.

(Clarifications about figure: the triangle is an isosceles triangle with height  $d$  and base  $2d$ .)

4. Suppose that we have the following cube with edges of length  $d$ . Write the transformations  $A, B, C$  between the coordinate systems :

$$\begin{pmatrix} X_A \\ Y_A \\ Z_A \\ 1 \end{pmatrix} = A \begin{pmatrix} X_B \\ Y_B \\ Z_B \\ 1 \end{pmatrix}, \quad \begin{pmatrix} X_C \\ Y_C \\ Z_C \\ 1 \end{pmatrix} = B \begin{pmatrix} X_A \\ Y_A \\ Z_A \\ 1 \end{pmatrix}, \quad \begin{pmatrix} X_C \\ Y_C \\ Z_C \\ 1 \end{pmatrix} = C \begin{pmatrix} X_B \\ Y_B \\ Z_B \\ 1 \end{pmatrix}.$$



You can solve the problem with the rotation column interpretation method or with concatenation of rotations.

*(Clarifications about the configuration:  $X_A, Y_A$  lie on the cube's edges. Similarly  $X_B, Y_B$  lie on the cube's edges.  $X_C$  is looking up and vertical to the cube's face and  $Y_C$  lies on the cube's face diagonal.)*