CIS 580 Homework 2
Due: 2/25

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1 Camera Rotation

1.1 Single Vanishing Point

In order to get the z vanishing point we take the two points on each set of parallel lines in the image. Since we can define the parallel lines we can find their intersection

$$l_1 = \begin{pmatrix} 332 & 577 & 1 \\ 119 & 783 & 1 \end{pmatrix}$$
$$l2 = \begin{pmatrix} 471 & 578 & 1 \\ 655 & 791 & 1 \end{pmatrix}$$
$$v_z = l_1 \times l_2$$
$$v_z = \begin{pmatrix} 407.25967 \\ 504.2136 \end{pmatrix}$$

Now that we have the pixel position of the vanishing we can calculate the pan and tilt angle

$$d * v_z = KX$$
$$K^{-1} v_z = r_3$$
$$K^{-1} * v_z = \begin{vmatrix} 02734358 \\ -0.00914 \\ 1 \end{vmatrix} = r_3$$
$$\alpha = \arctan(r_3(1)/r_3(3))$$
$$\beta = \arcsin(r_3(2))$$
$$\alpha = 0.0273 rads$$
$$\beta = -0.0091 rads$$

1.2 Two Vanishing Points

Similar to section 1 we find the cross product of the x direction parallel lines for vx and the cross produce of y direction parallel lines to calculate vy

$$l_x(1) = \begin{pmatrix} 63 & 324 & 1 \\ 446 & 441 & 1 \end{pmatrix}, l_x(2) = \begin{pmatrix} 20 & 525 & 1 \\ 436 & 635 & 1 \end{pmatrix}$$

$$l_y(1) = \begin{pmatrix} 214 & 297 & 1 \\ 52 & 679 & 1 \end{pmatrix}, l_y(2) = \begin{pmatrix} 388 & 351 & 1 \\ 329 & 745 & 1 \end{pmatrix}$$

$$v_x = l_x(1) \times l_x(2) = \begin{pmatrix} 5235.2 \\ 1904 \\ 1 \end{pmatrix}$$

$$v_y = l_y(1) \times l_y(2) = \begin{pmatrix} 495.4775 \\ -366.7308 \\ 1 \end{pmatrix} K^{-1} v_x = r_1$$

$$K^{-1} v_y = r_2$$

$$r_3 = r_1 \times r_2$$

$$r_1(2) = \cos(\beta)\sin(\gamma)$$

$$r_2(2) = \cos(\beta)\cos(\gamma)$$

$$\tan(\gamma) = r_1(2)/r_2(2)$$

$$\gamma = \arctan(r_1(2)/r_2(2)) = -0.3709$$

$$\alpha = \arctan(r_3(1)/r_3(3)) = -0.4303$$

$$\beta = -\arcsin(r_3(2)) = 0.7158$$

2 Homography

2.1 Find point t infinity in homogenous coordinate and point in world coordinate

Since the two lines are parallel in the image they intersect at infinity and we would represent this in homogenous coordinates as

$$\begin{pmatrix} x \\ y \\ w \end{pmatrix}$$

where w is equal to 0

$$\begin{pmatrix} 0 \\ 1 \\ 0 \end{pmatrix}$$

$$inf_point = \begin{pmatrix} 0 \\ 1 \\ 0 \end{pmatrix} = KH_1 \begin{pmatrix} X_w \\ Y_w \\ Z_w \end{pmatrix}$$

$$H^{-1}K^{-1}inf_point = \begin{pmatrix} X_w \\ Y_w \\ Z_w \end{pmatrix}$$

$$\begin{pmatrix} X_w \\ Y_w \\ Z_w \end{pmatrix} = \begin{pmatrix} 0.1037 \\ -.3815 \\ 1 \end{pmatrix}$$

2.2 Find Rotation matrix for 45 degree tilt

In SO3 an x axis rotation can be defined as

$$R = \begin{pmatrix} 1 & 0 & 0 \\ 0 & \cos(45) & -\sin(45) \\ 0 & \sin(45) & \sin(45) \end{pmatrix} = \begin{pmatrix} 1 & 0 & 0 \\ 0 & \frac{\sqrt{2}}{2} & -\frac{\sqrt{2}}{2} \\ 0 & \frac{\sqrt{2}}{2} & \frac{\sqrt{2}}{2} \end{pmatrix}$$

2.3 Find H that maps image plane A to image plane B

since we know

$$x_b = KR\lambda_b H_1 X$$
$$x_a = K\lambda_a H_1 X$$
$$K^{-1}x_a = \lambda H_1 X$$
$$x_b = \lambda KRK^{-1}x_a$$
$$H = KRK^{-1}x_a$$

Then we must normalize by the last element inH_{ab}

$$H_{ba} = H/H_{(3,3)}$$

2.4 find line in image plane B homogenous coordinates

We can combine homographies H_ba and H_1 to make a Homography H_b1 which transforms points from world coordinate frame to image B

$$l_b = (H_1 H_{ba})^{-T} l_w$$
$$l_b = (H_b 1)^{-T} l_w$$

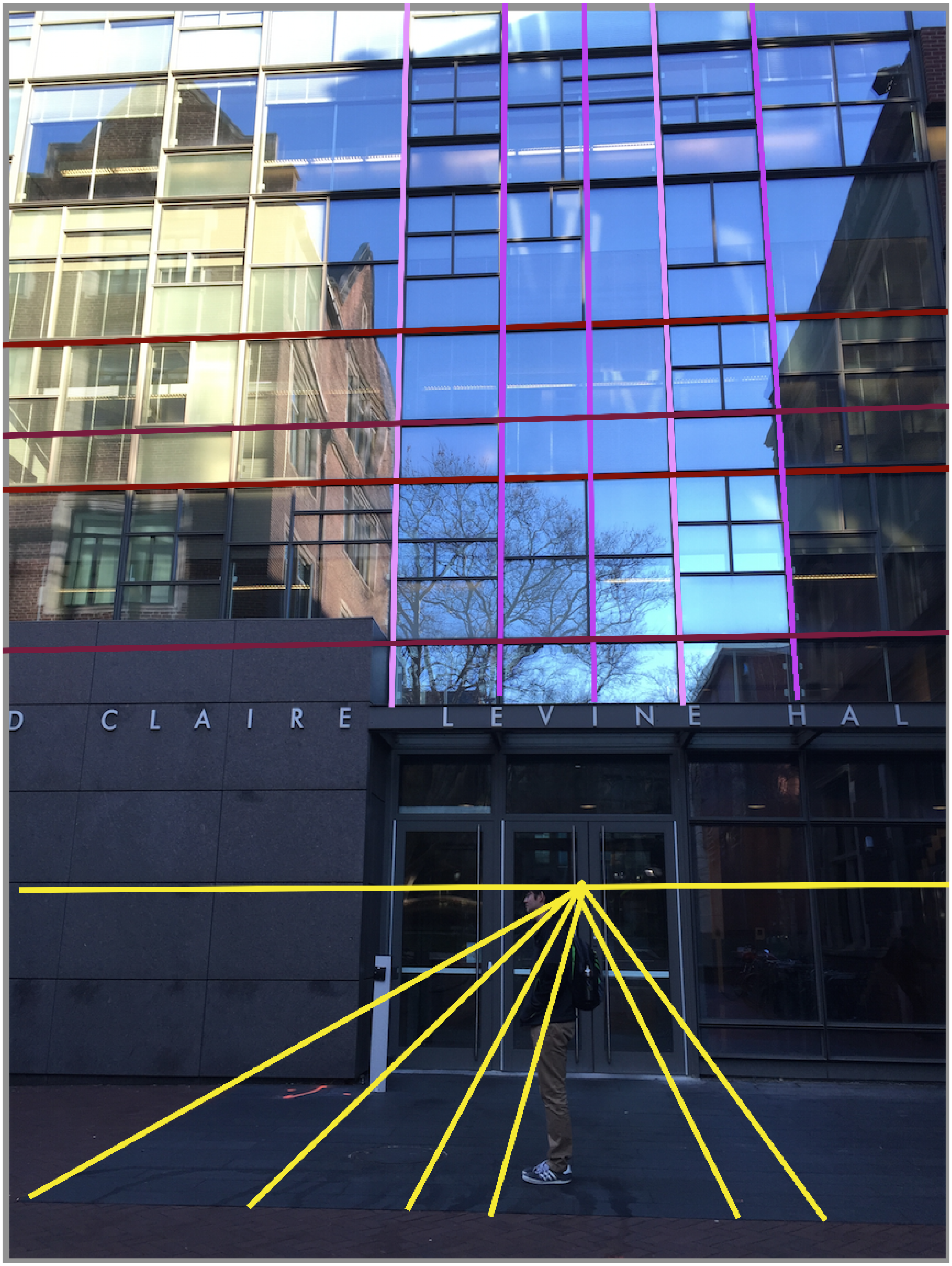
$$l_1 = \begin{pmatrix} -0.3559 \\ 0.1436 \\ 0 \end{pmatrix} l_2 = \begin{pmatrix} -0.3887 \\ 0.1614 \\ 0 \end{pmatrix}$$

2.5 Compute the intersection of these two radiating lines on image plane B. Are they converging or diverging?

$$
\begin{aligned}
isx &= l_1 \times l_2 \\
isx &= -0.0016
\end{aligned}
$$

This means the radiating lines are converging on image B

3 Find height of Levine Door



Calculate Height of Levine Door

Since I took the photo not perpendicular to the ground plane we can calculate the vertical vanishing point. Using the purple lines on the vertical feature on the building I calculated they intersect at $1281.2 pixels$ Since I know my friends height is 180 cm, we can use the cross ratio to calculate the doors height.

$$l_y(1) = \begin{pmatrix} 1685 & 120 & 1 \\ 1754 & 1765 & 1 \end{pmatrix}, l_y(2) = \begin{pmatrix} 1041 & 100 & 1 \\ 999 & 1780 & 1 \end{pmatrix}$$

$$v_y = 1281.2$$

$$\text{Cross Ratio to calculate}$$

$$r = 1695, b = 2491, t = 1539$$

$$\frac{H}{R} = \frac{||t-b||||v_y - r||}{||r-b||||v_y - t||} = 2.1079$$

$$R = 1800mm$$

$$H = R * \frac{||t-b||||v_y - r||}{||r-b||||v_y - t||} = 3794.2mm$$