CS 763: Assignment 2

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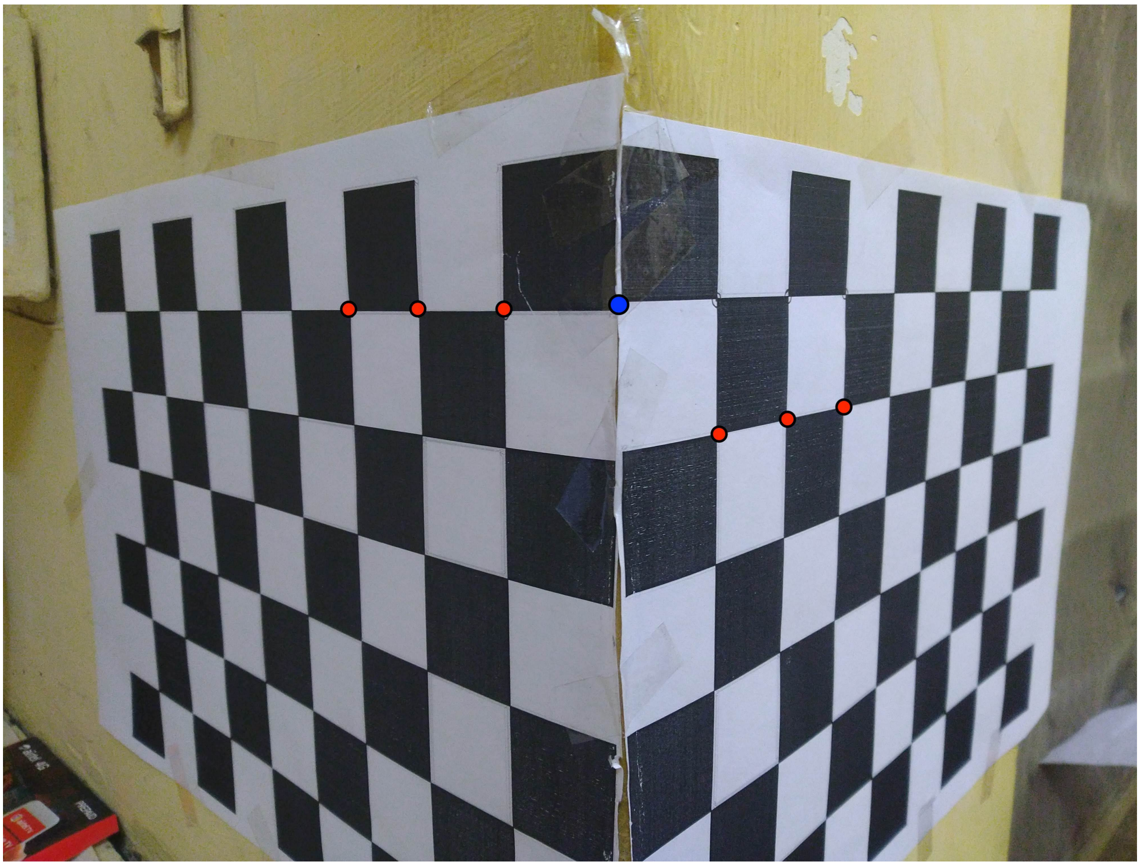
Question 1



Consider the 6 points marked with red circle in the figure. Blue circle corresponds to origin in world coordinate system. Z axis is towards left, Y is upwards and -ve X is towards right.

Their 3D positions and corresponding 2D image co-ordinates are:

3D	2D
(0,0,3)	(1.2287, 1.0846)
(0,0,2)	(1.4746, 1.0846)
(0,0,1)	(1.7746, 1.0966)
(-1,-1,0)	(2.5244, 1.0426)
(-2,-1,0)	(2.7763, 1.0306)
(-3,-1,0)	(2.9803, 1.0246)

To normalize 3D points, we use the following transformation

$$U = \begin{bmatrix} 1.0584 & 0 & 0 & 1.0584 \\ 0 & 1.0584 & 0 & 0.5292 \\ 0 & 0 & 1.0584 & -1.0584 \\ 0 & 0 & 0 & 1.0000 \end{bmatrix} \tag{1}$$

To normalize 2D points, we use the following transformation

$$T = \begin{bmatrix} 2.1274 & 0 & -4.5197 \\ 0 & 2.1274 & -2.7199 \\ 0 & 0 & 1.0000 \end{bmatrix} \tag{2}$$

Normalized projection matrix obtained using DLT,

$$\hat{\mathbf{P}} = \begin{bmatrix} -0.0164 & 0.8393 & -0.2141 & 0.2393 \\ 0.0015 & 0.1396 & -0.0158 & 0.0700 \\ -0.0027 & -0.3817 & 0.0300 & -0.1447 \end{bmatrix} \tag{3}$$

After denormalizing,

$$\begin{aligned} \mathbf{P} &= T^{-1}\hat{\mathbf{P}}U \\ &= \begin{bmatrix} -0.0142 & -0.4408 & -0.0390 & -0.3905 \\ -0.0029 & -0.4471 & 0.0327 & -0.4113 \\ -0.0028 & -0.4040 & 0.0318 & -0.3813 \end{bmatrix} \end{aligned} \tag{4}$$

As discussed in class, P can be decomposed to get intrinsic and extrinsic parameters.

$$\begin{aligned} X_o &= (-16.2329, -0.6106, 2.7888) \\ R &= \begin{bmatrix} -0.9615 & -0.1962 & -0.1922 \\ 0.2743 & -0.7229 & -0.6342 \\ -0.0145 & -0.6625 & 0.7489 \end{bmatrix} \\ K &= \begin{bmatrix} 0.1809 & -0.2325 & -6.4459 \\ 0 & 0.0058 & 0.1189 \\ 0 & 0 & 1.0000 \end{bmatrix} \end{aligned} \tag{5}$$

RMSE between the 2D points marked and the estimated 2D projections of the marked 3D points is $5.8339e{-}06$

Question 2

The dimensions of the field were estimated as, **110yd** $\times$ **75yd**(approximately).
To run the code, run ***myMainScript.m***, select the four corners of the outer Dee when prompted and select the three visible corners of the field in order. The script prints the estimated values.

Question 3

We use the invariance of cross-ratios to estimate the dimensions. To estimate the width of the field, consider the line $\mathbf{A'B'C'D'}$ and its real world counterpart. The cross-ratio of the projected line is given by

$$= \frac{\mathbf{A'C'}}{\mathbf{A'D'}} \times \frac{\mathbf{B'D'}}{\mathbf{B'C'}}$$

The pixel coordinates are: $\mathbf{A'}(1024, 810)$, $\mathbf{B'}(1058, 719)$, $\mathbf{A'}(1124, 554)$, $\mathbf{A'}(1140, 515)$. Therefore the cross-ratio is,

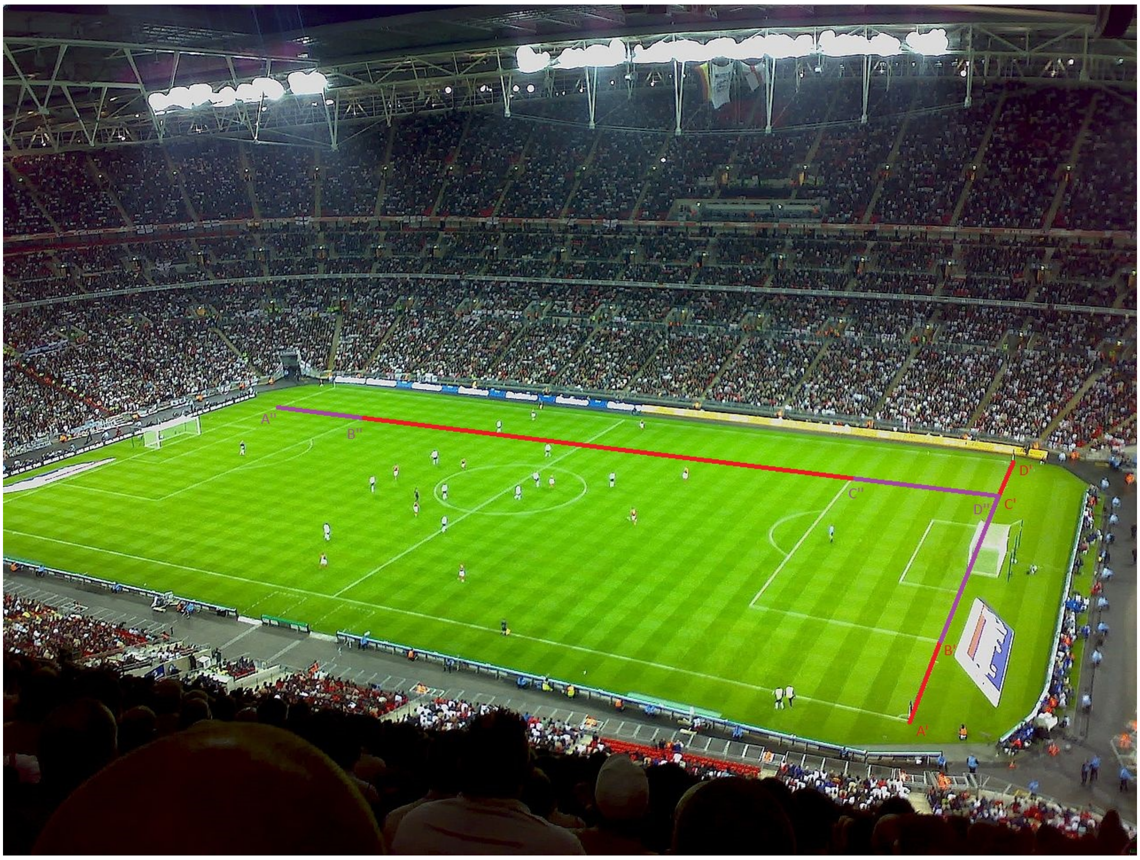
$$= \frac{274.84}{316.99} \times \frac{219.86}{177.71} = 1.07$$

Assume the real world line is **ABCD**, with **BC** being the outer Dee part. Let $\mathbf{AB} = \mathbf{CD} = x$ yards, which gives us

$$\frac{(44+x)}{(44+2x)} \times \frac{(44+x)}{(44)} = 1.07$$

This gives us the quadratic equation,

$$x^2 - 6.16x - 135.52 = 0$$



$$\implies x = 15.12$$

Therefore the estimated width given by $44 + 2x =$ **74.24** yards (approx. 75 yards).
To estimate the length of the field, consider the line **A″B″C″D″** and its real world counterpart. Assume again that the real-world line is **ABCD**, with **AB**=**CD**= 18 yards and **BC**= x. Applying the same concept as above we got,

$$\frac{(x+18)}{(x+36)} \times \frac{(x+18)}{x} = 1.04$$

$$\implies 0.04x^2 + 1.44x - 324 = 0$$

$$\implies x = 73.78$$

Therefore the estimated length of the field given by $x + 2 \times 18 =$ **109.78** yards (approx. 110 yards).

Question 4

The stitched images are in the output folder of the corresponding question. We have tried stitching two images we took using our own phone. The images are in the input/kalaghoda folder and the output is output/kalaghoda.jpg.