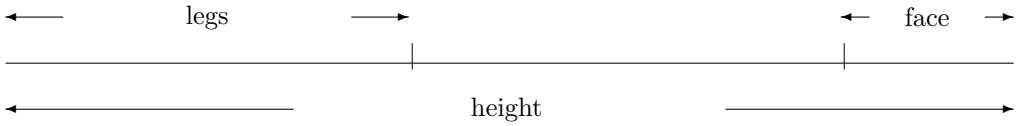
**Homework-9 Solutions**

# Question 1

You are given the following information about a famous tennis player: His height is 210 cm, his legs are 90 cm. long, and the length of his face is 30 cm. The following diagram illustrates these measurements:




$$CR = \frac{90 \times 30}{180 \times 120} = 1/8 = 0.125$$

Measurements were taken from images of 5 tennis players. The images are distorted by perspective projection:

**t1** height is 6 cm, legs are 2.2 cm. long, and length of face is 2 cm. $CR = 0.289$

**t2** height is 7 cm, legs are 2 cm. long, and length of face is 2 cm. $CR = 0.16$

**t3** height is 10 cm, legs are 2 cm. long, and length of face is 1 cm. $CR = 0.028$

**t4** height is 4.2 cm, legs are 1 cm. long, and length of face is 1.2 cm. $CR = 0.125$

**t5** height is 17 cm, legs are 9 cm. long, and length of face is 4 cm. $CR = 0.346$

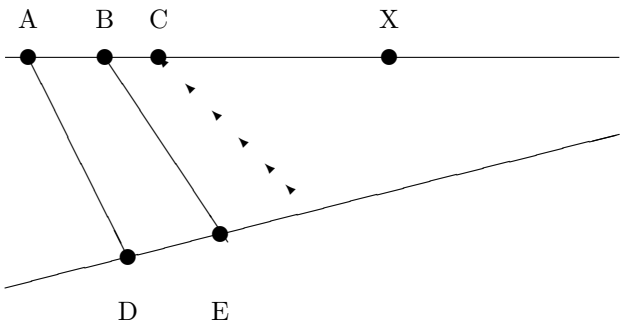
**a.** Which image (from t1,t2,t3,t4, t5) is more likely to be the tennis player than all the others?

**Answer:** t4

**b.** Which image (from t1,t2,t3,t4, t5) is the second most likely to be the tennis player?

**Answer:** t2

# Question 2




The above image shows a segment of a railroad, distorted by perspective projection.

The following information is known about the camera. Its focal distance $f = 1$, and the principal point (the camera location in the image) is at $u = 0$, $v = 50$.

**Part 1**

The following information is known about the location of points in the image:

| | u | v |
|---|---|---|
| A | 0 | 0 |
| B | 10 | 0 |
| D | 10 | 10 |
| E | 14 | 8 |

compute the 3D direction of the rails.

**Answer:**

The line DE is: $v - 10 = \frac{8-10}{14-10}(u - 10)$. The vanishing point is at $v = 0$ because of the line AB, and this gives $u = 30$. Therefore the vanishing point is $(30, 0)$. The 3D direction is: $\begin{pmatrix} 30 \\ -50 \\ 1 \end{pmatrix}$ Normalized: $\begin{pmatrix} 0.514 \\ -0.857 \\ 0.017 \end{pmatrix}$

**Part 2**

You are given the following information about the location of points in the image:

| | u | v |
|---|---|---|
| A | 0 | 0 |
| B | 9 | 0 |
| C | 16 | 0 |
| X | 23 | 0 |

You also know that the distance between the ties (the 3D locations of A and B and the 3D locations of B and C) is one meter. Compute the distance of the point X from A.

**Answer:**

$$\text{CR} = \frac{9 \cdot 7}{16 \cdot 14} = 0.28125 = \frac{1 \cdot (u-2)}{2 \cdot (u-1)}$$

this gives $u = 3.28$.

**Part 3**

You are given the following information about the location of points in the image:

| | u | v |
|---|---|---|
| A | 0 | 0 |
| B | 9 | 0 |
| C | 16 | 0 |

You also know that the distance between the ties (the 3D locations of A and B and the 3D locations of B and C) is one meter, and the camera calibration parameters are the same as was specified above.

Is it possible to use this information to compute the 3D direction of the rails? If your answer is NO, explain why? If your answer is YES, compute the 3D direction of the rails.

**Answer:**

Mark by $u$ the 2D distance from $A$, and by $X$ the 3D distance from $A$.

$$\frac{9 \cdot (u-16)}{16 \cdot (u-9)} = \frac{1 \cdot (X-2)}{2 \cdot (X-1)} \longrightarrow_{X \to \infty} \frac{1}{2}$$

from this we get $u = 72$, and the 3D direction is $\begin{pmatrix} 72 \\ -50 \\ 1 \end{pmatrix}$.