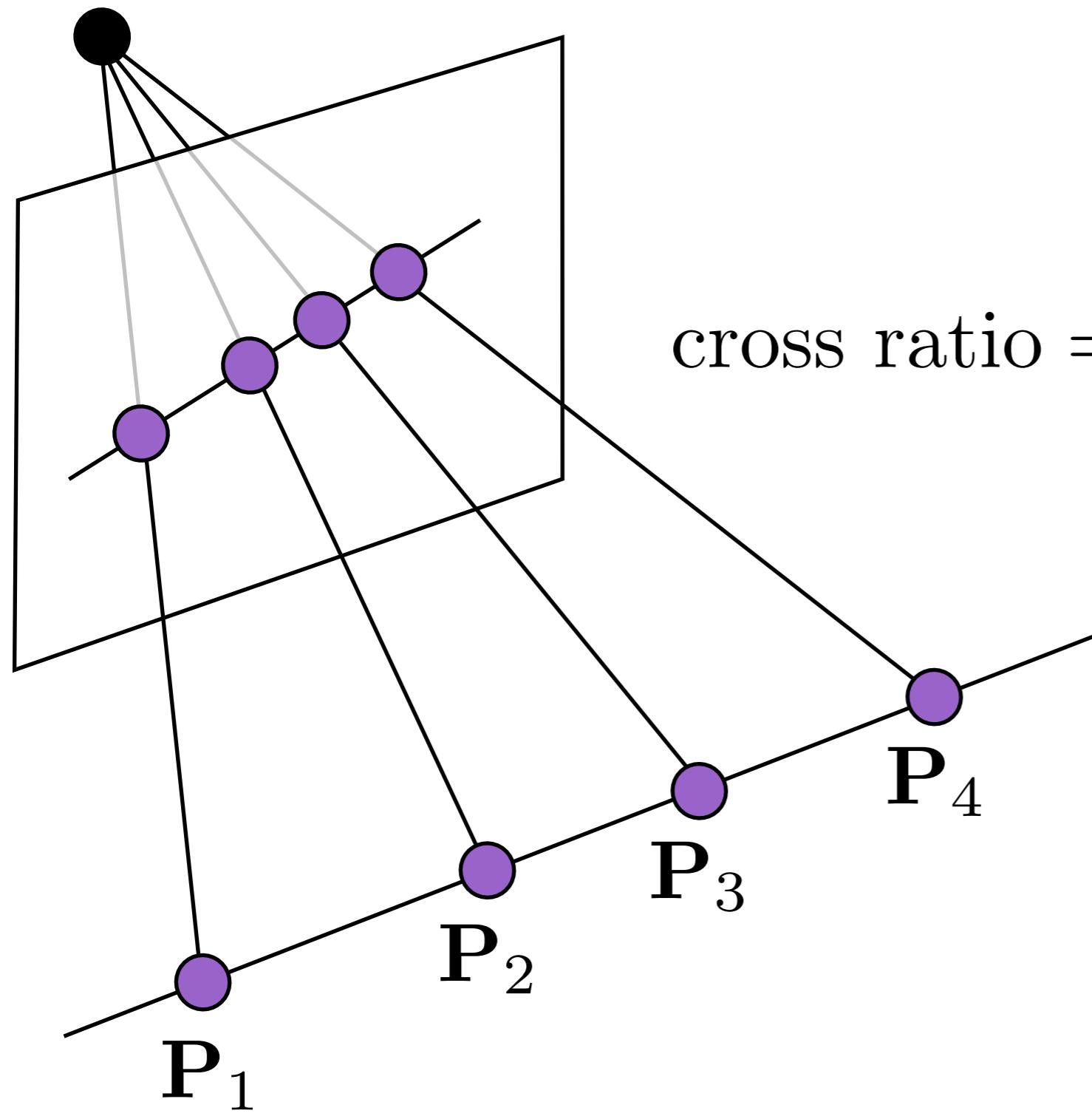


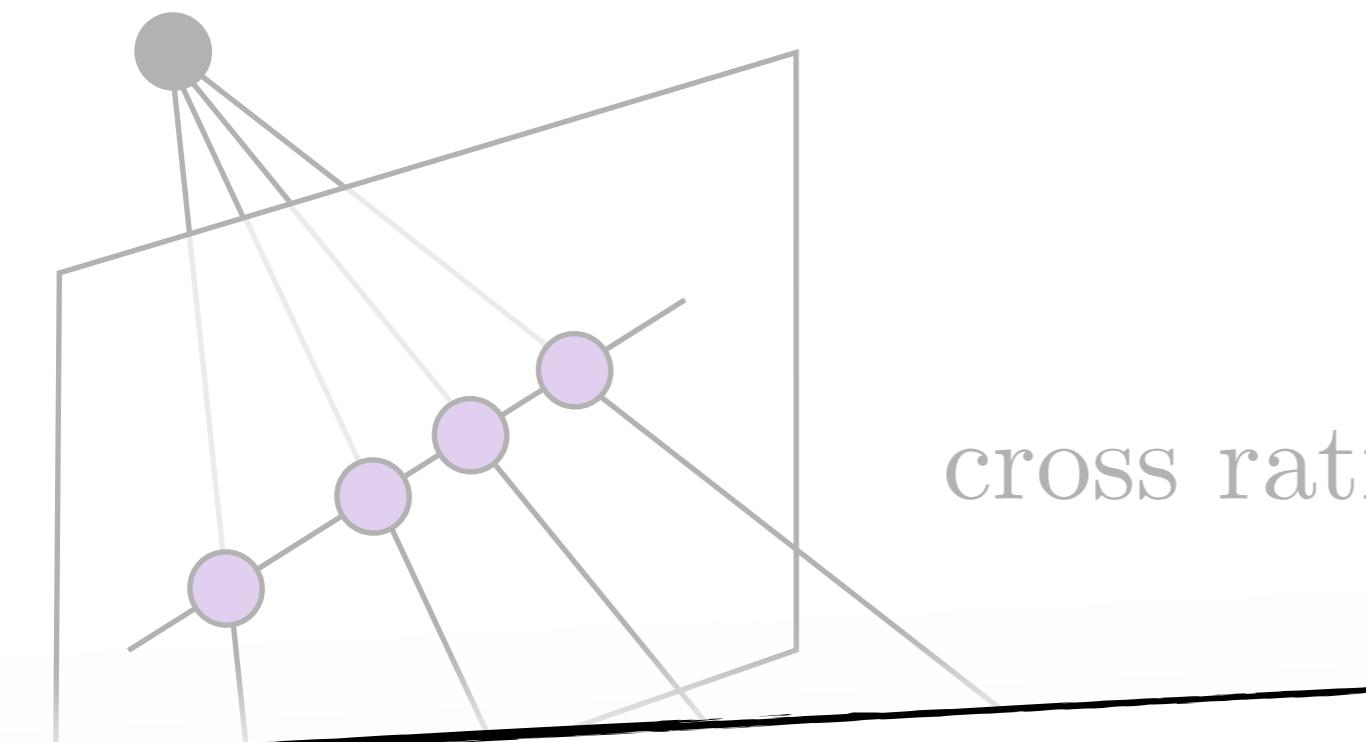
**metrology**  
**the science of measurement**

*cross ratio*



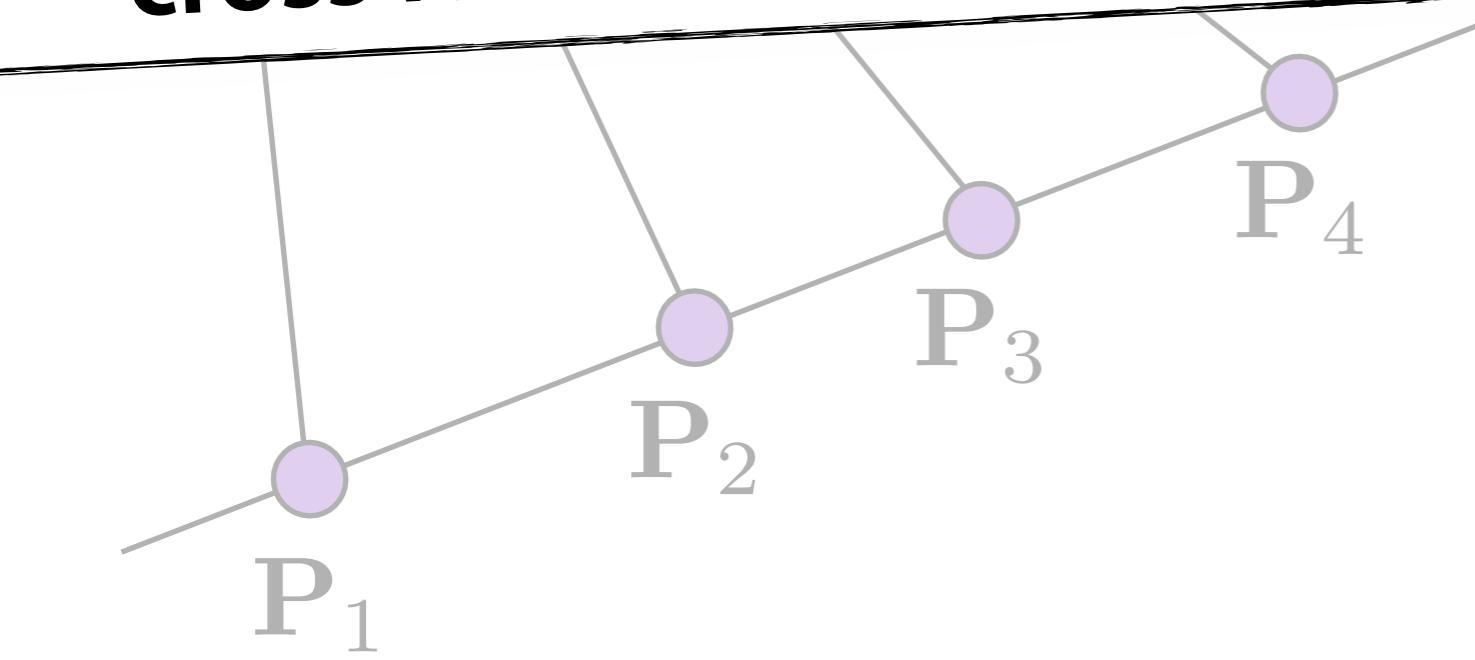
$$\text{cross ratio} = \frac{\|P_3 - P_1\| \|P_4 - P_2\|}{\|P_3 - P_2\| \|P_4 - P_1\|}$$

*cross ratio*

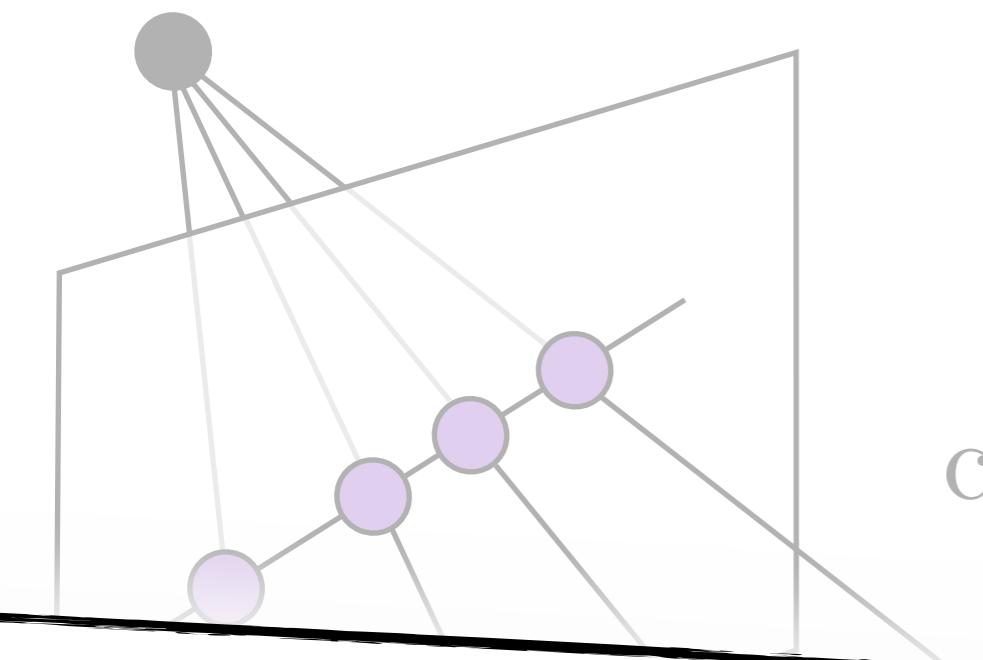


$$\text{cross ratio} = \frac{\|P_3 - P_1\| \|P_4 - P_2\|}{\|P_3 - P_2\| \|P_4 - P_1\|}$$

**cross ratio is invariant under perspective projection**

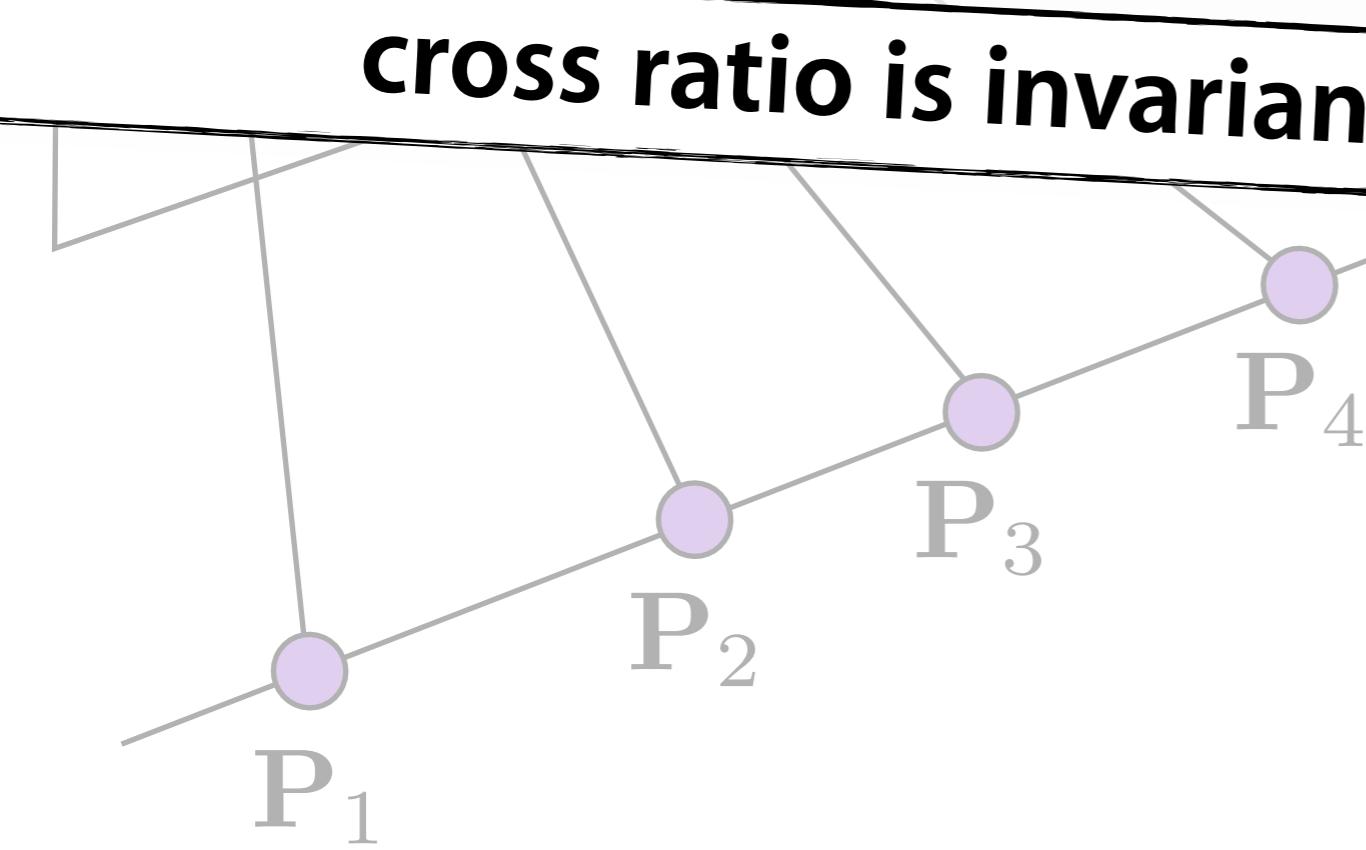


*cross ratio*

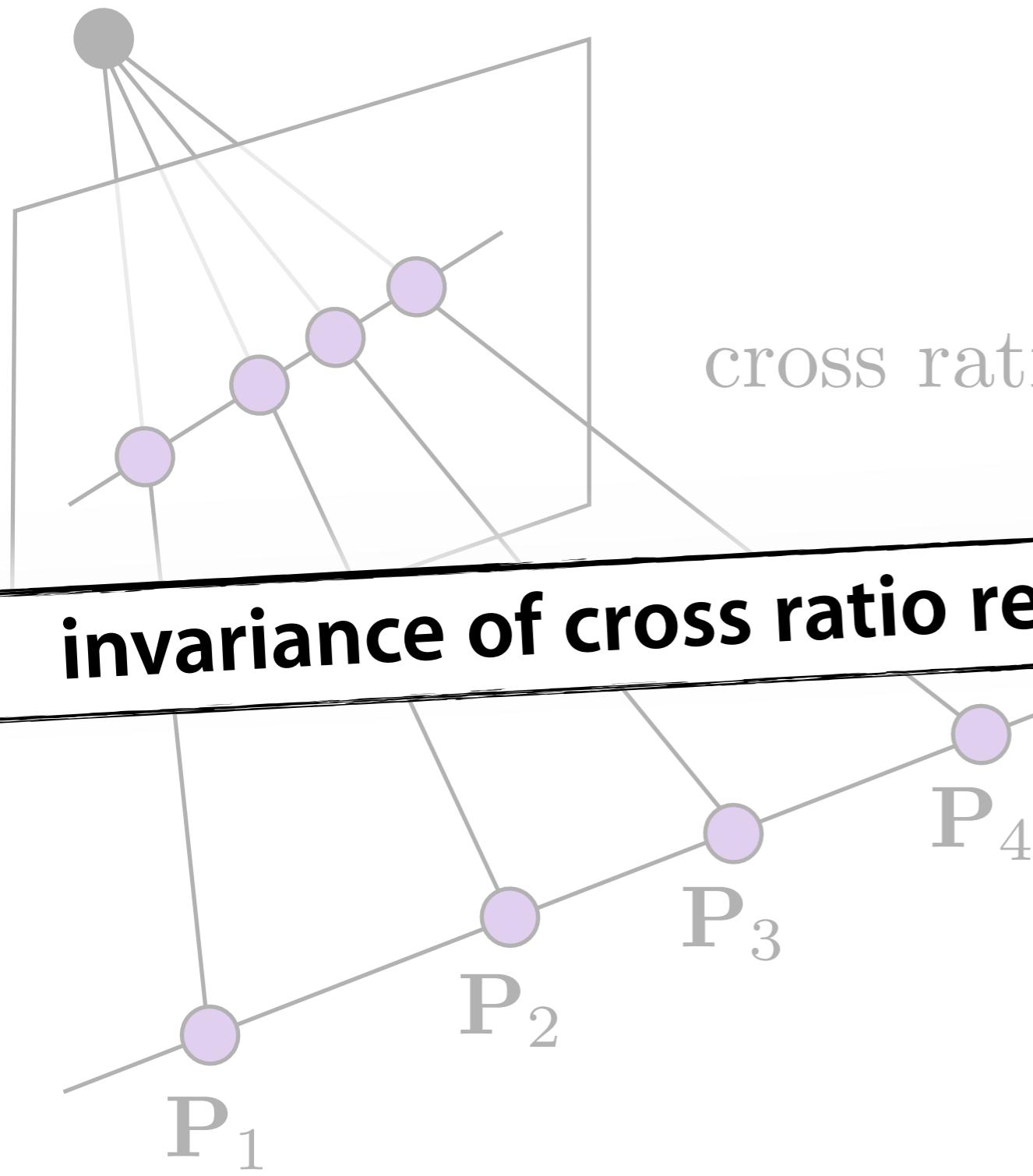


$$\text{cross ratio} = \frac{\|P_3 - P_1\| \|P_4 - P_2\|}{\|P_3 - P_2\| \|P_4 - P_1\|}$$

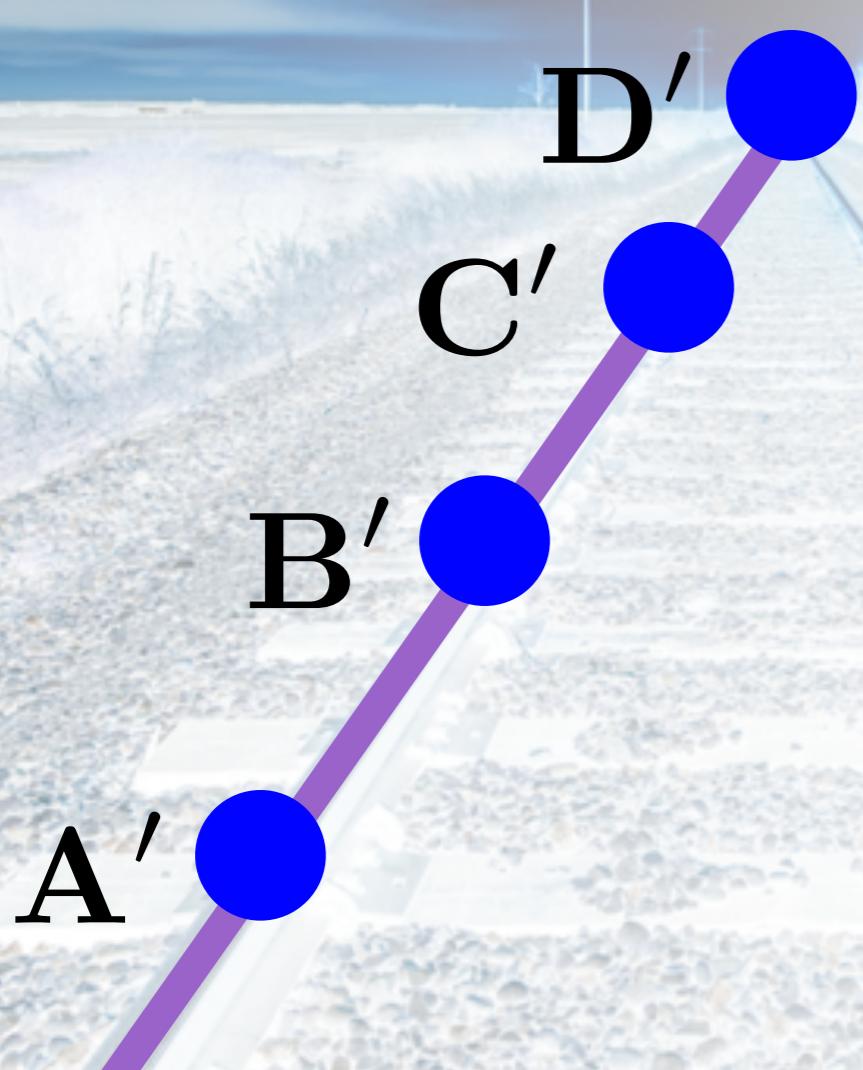
**cross ratio is invariant under homography**



*cross ratio*



$$\text{cross ratio} = \frac{\|P_3 - P_1\| \|P_4 - P_2\|}{\|P_3 - P_2\| \|P_4 - P_1\|}$$



**A'**

**B'**

**C'**

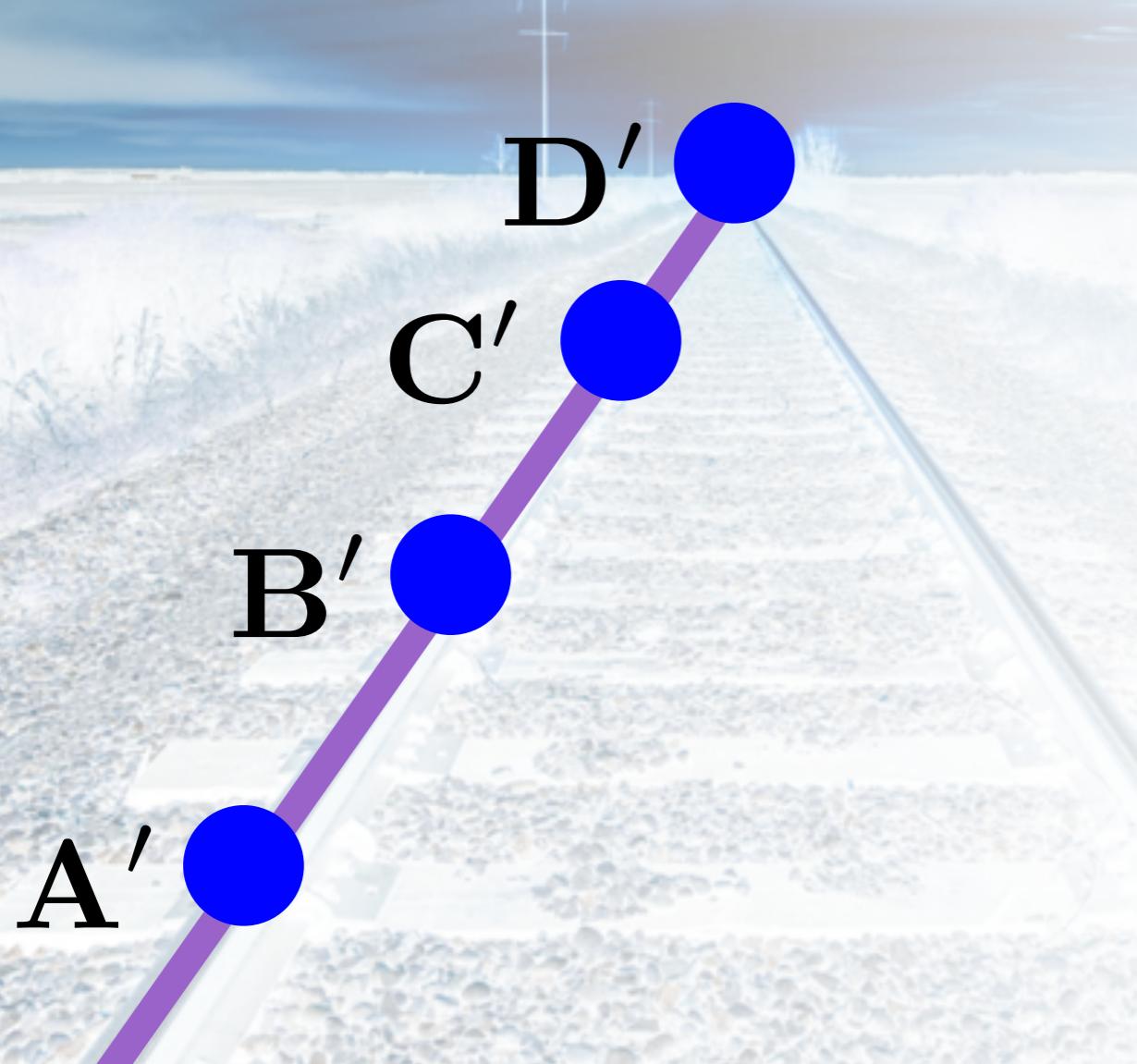
**D'**

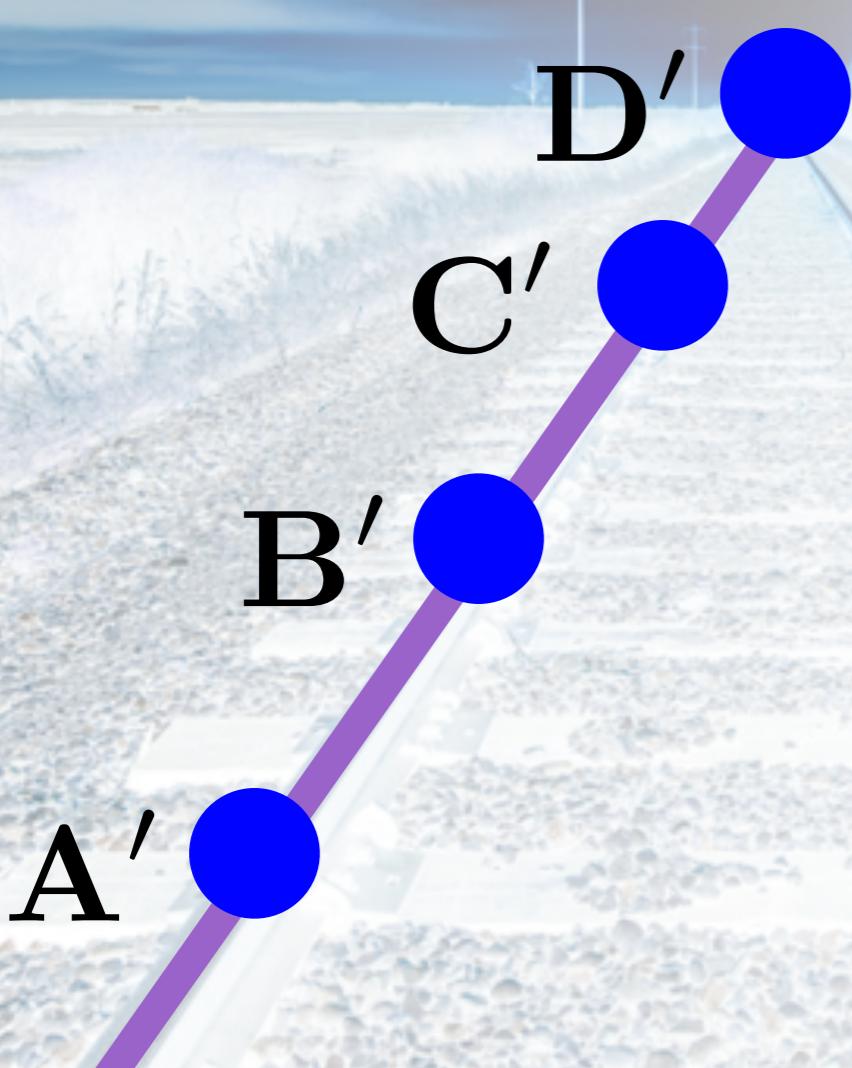
$$\frac{A'C'}{A'D'} : \frac{B'C'}{B'D'} = \frac{AC}{AD} : \frac{BC}{BD}$$

$$= \frac{AC}{BC} : \frac{\cancel{AD}}{\cancel{BD}}$$

1

$$= \frac{AC}{BC}$$





$$\frac{A'C'}{A'D'} : \frac{B'C'}{B'D'} = \frac{AC}{BC}$$



A'

B'

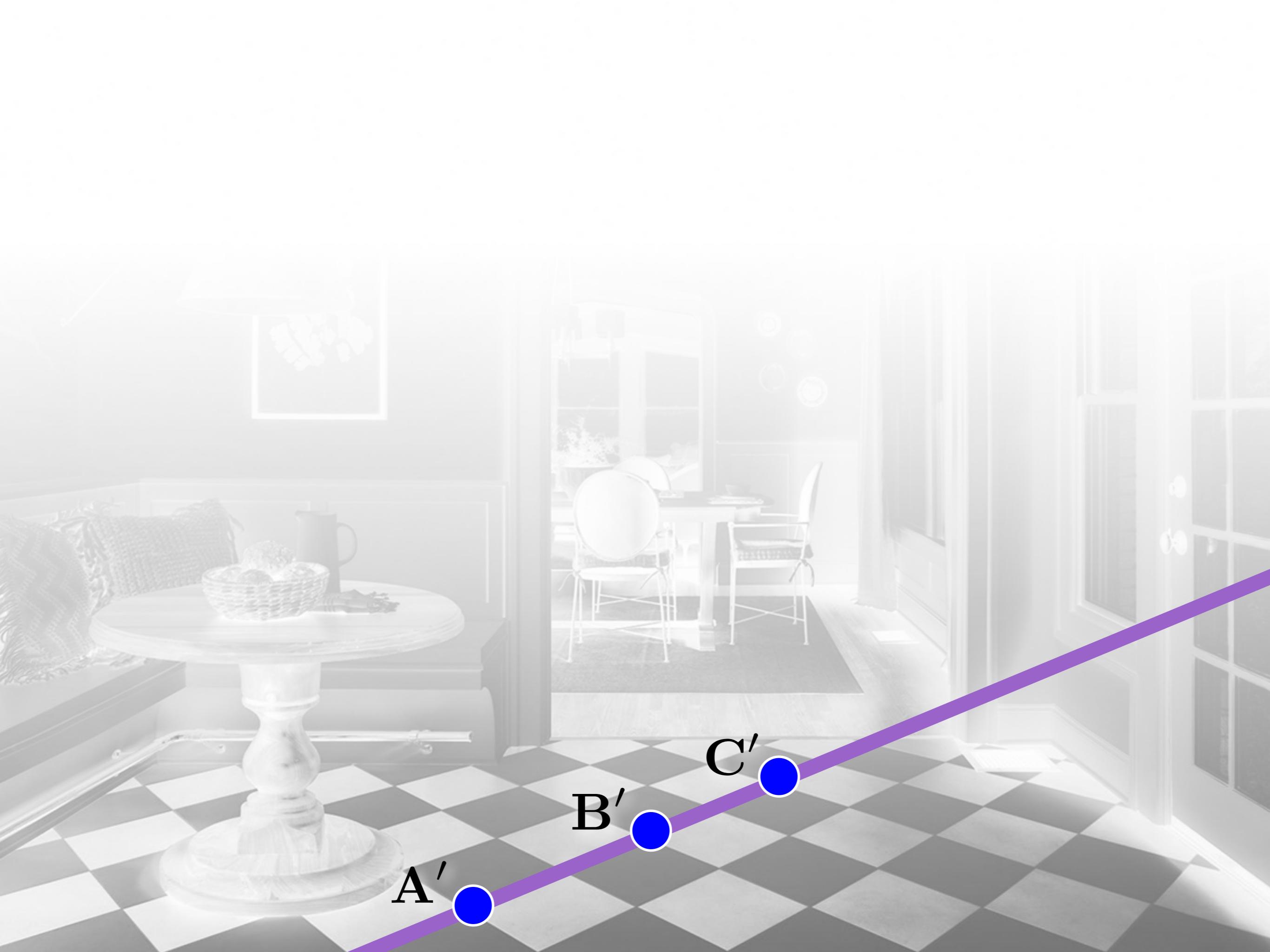
C'



B'

C'

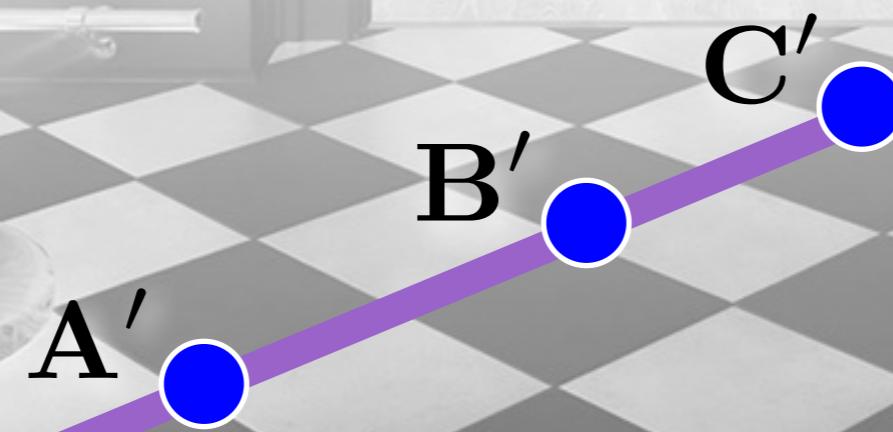
D'



A'  
B'  
C'

$$\frac{A'C'}{A'D'} : \frac{B'C'}{B'D'} = \frac{AC}{AD} : \frac{BC}{BD}$$

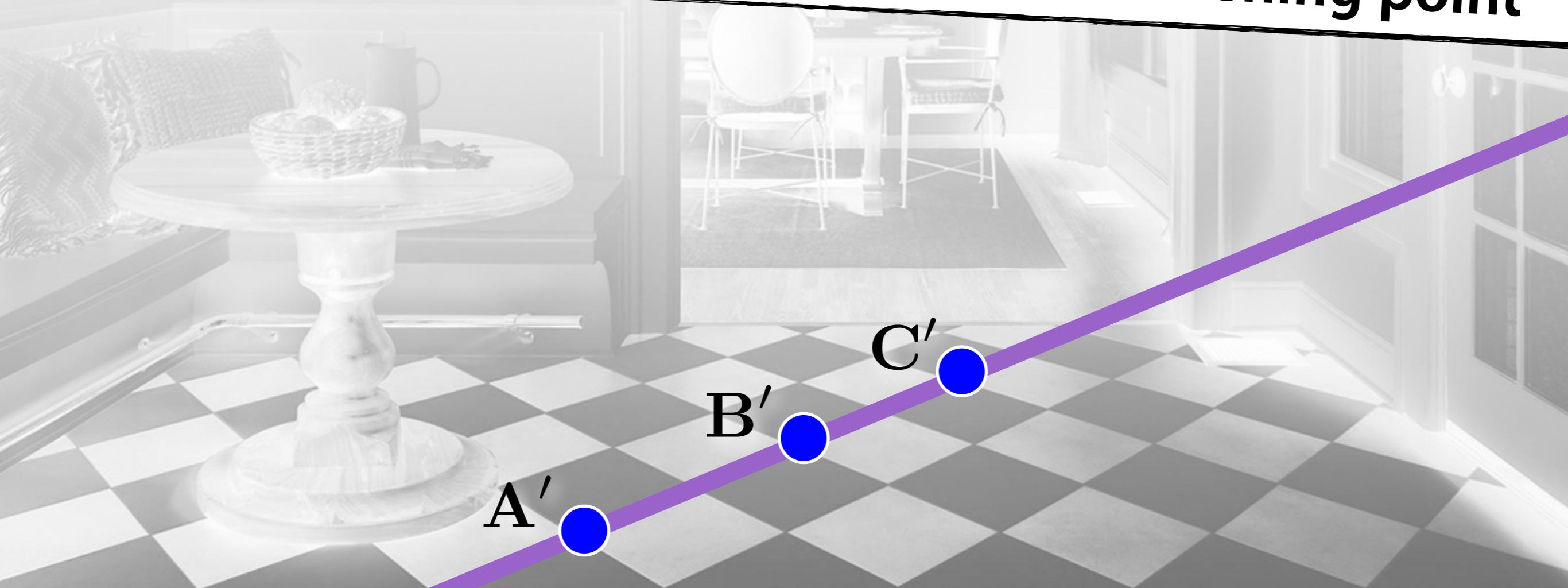
$$= \frac{AC}{BC} : \frac{\cancel{AD}}{\cancel{BD}} = 2$$



$$\frac{A'C'}{A'D'} : \frac{B'C'}{B'D'} = \frac{AC}{AD} : \frac{BC}{BD}$$

$$= \frac{AC}{BC} : \frac{\cancel{AD}}{\cancel{BD}} = 2$$

given the corners in pixels, can recover vanishing point





A'

B'

C'

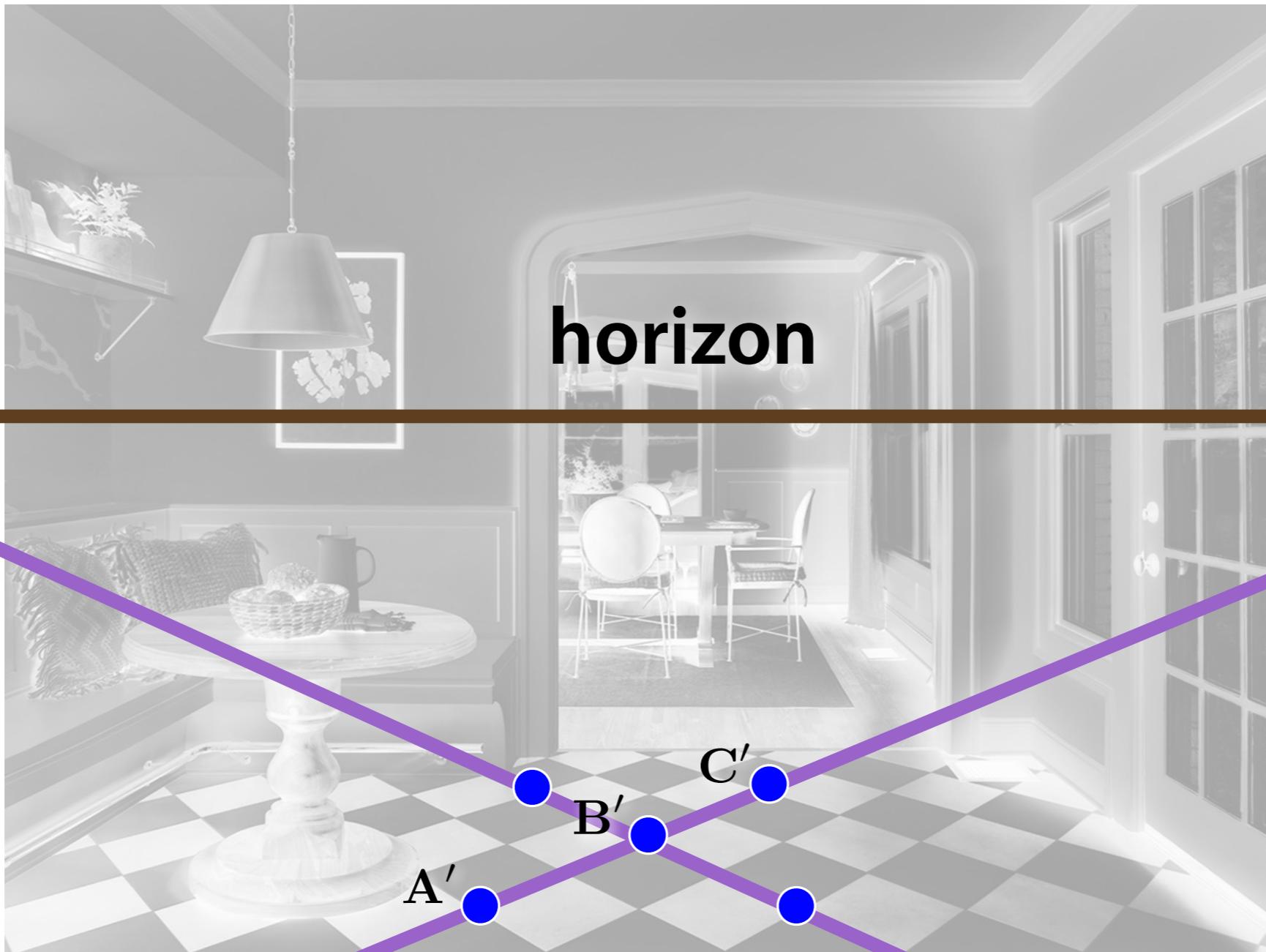


$A'$

$B'$

$C'$





**How far is the woman, B, from the telephone post, C?**

C'      B'      A'





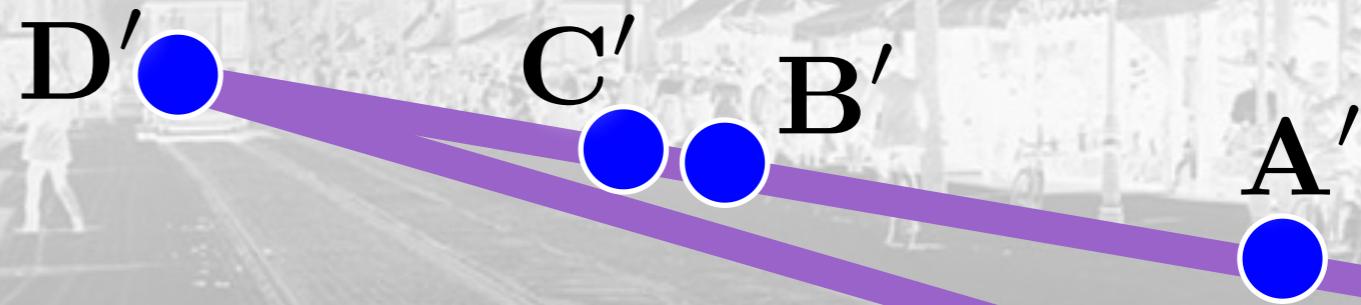
$$\frac{A'C'}{A'D'} : \frac{B'C'}{B'D'} = \frac{AC}{BC}$$

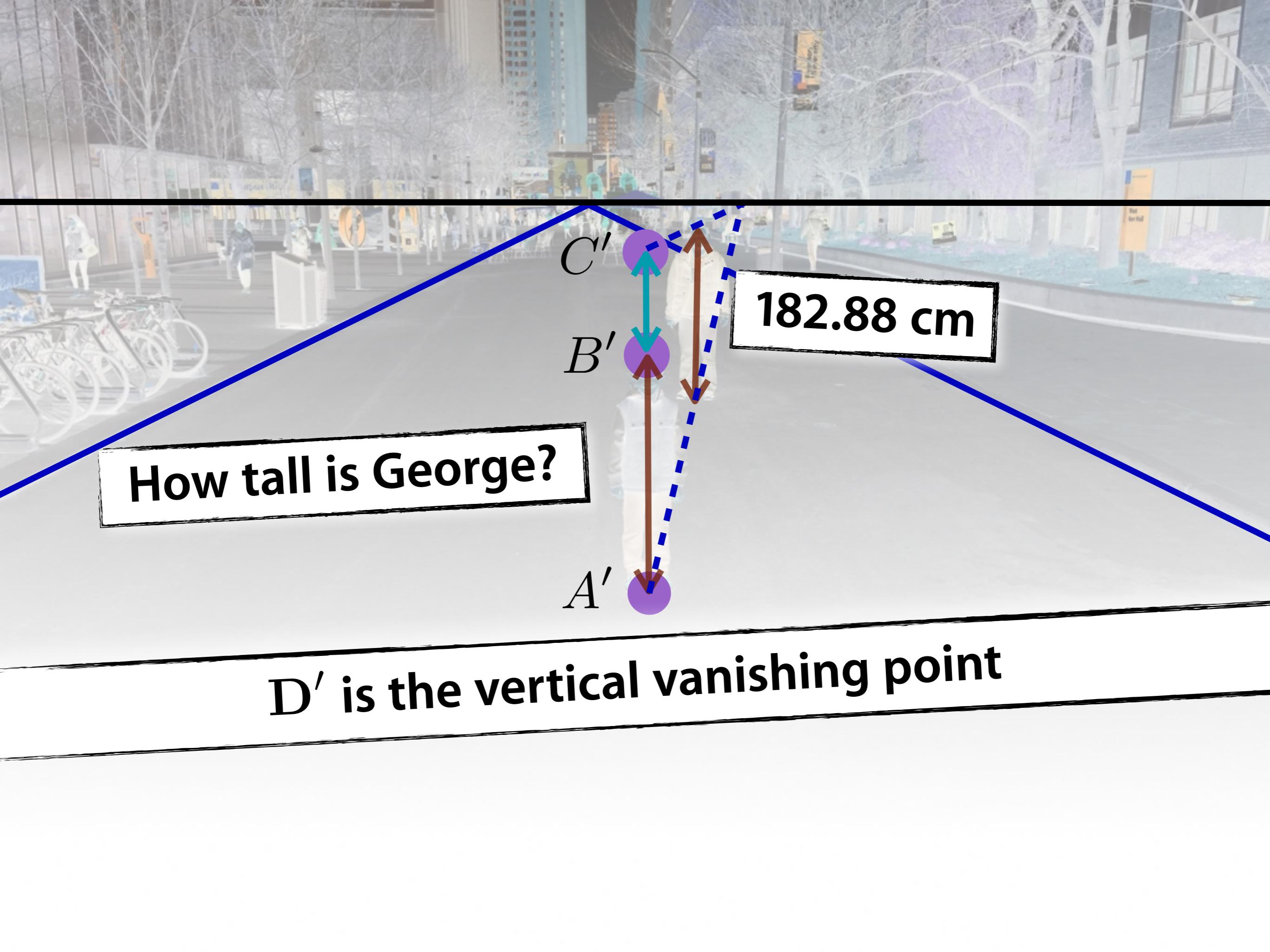


$$\frac{A'C'}{A'D'} : \frac{B'C'}{B'D'} = \frac{AC}{BC}$$

Given the lamp posts are 25 meters apart and  
the image points (in pixels)

$$BC = \frac{(AC)(A'D')(B'C')}{(A'C')(B'D')}$$





How tall is George?

182.88 cm

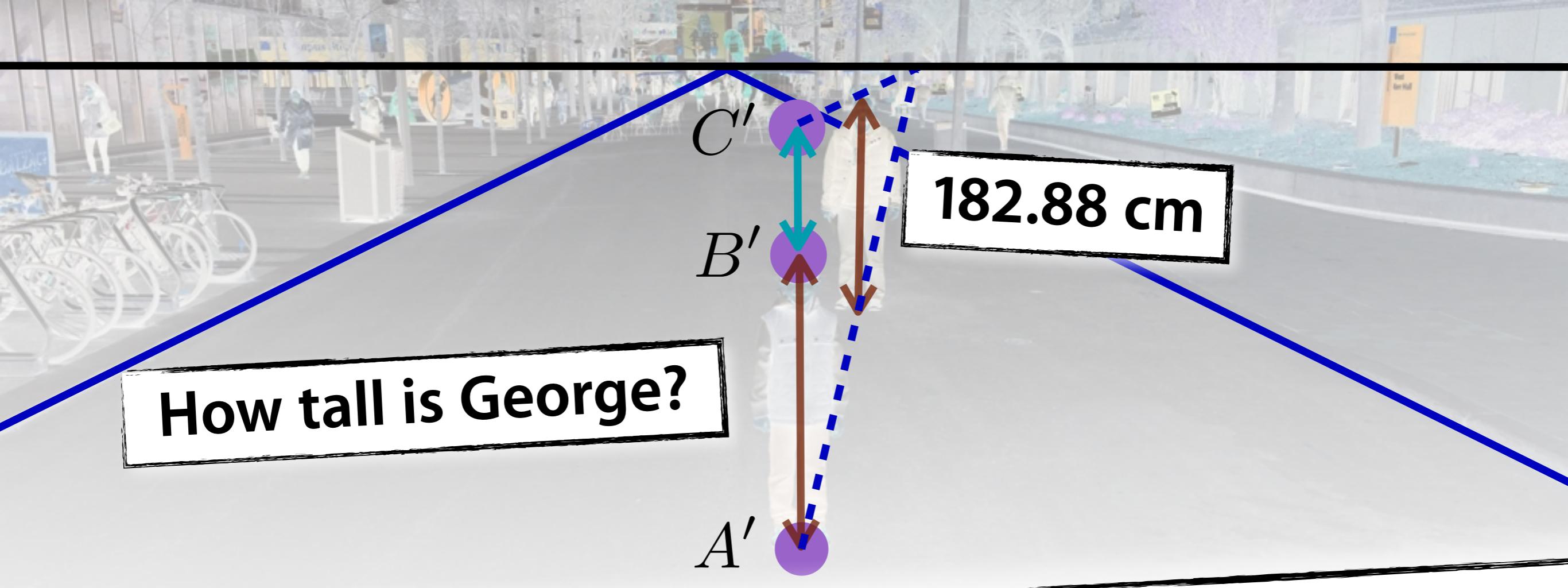
D' is the vertical vanishing point

How tall is George?

182.88 cm

D' is the vertical vanishing point

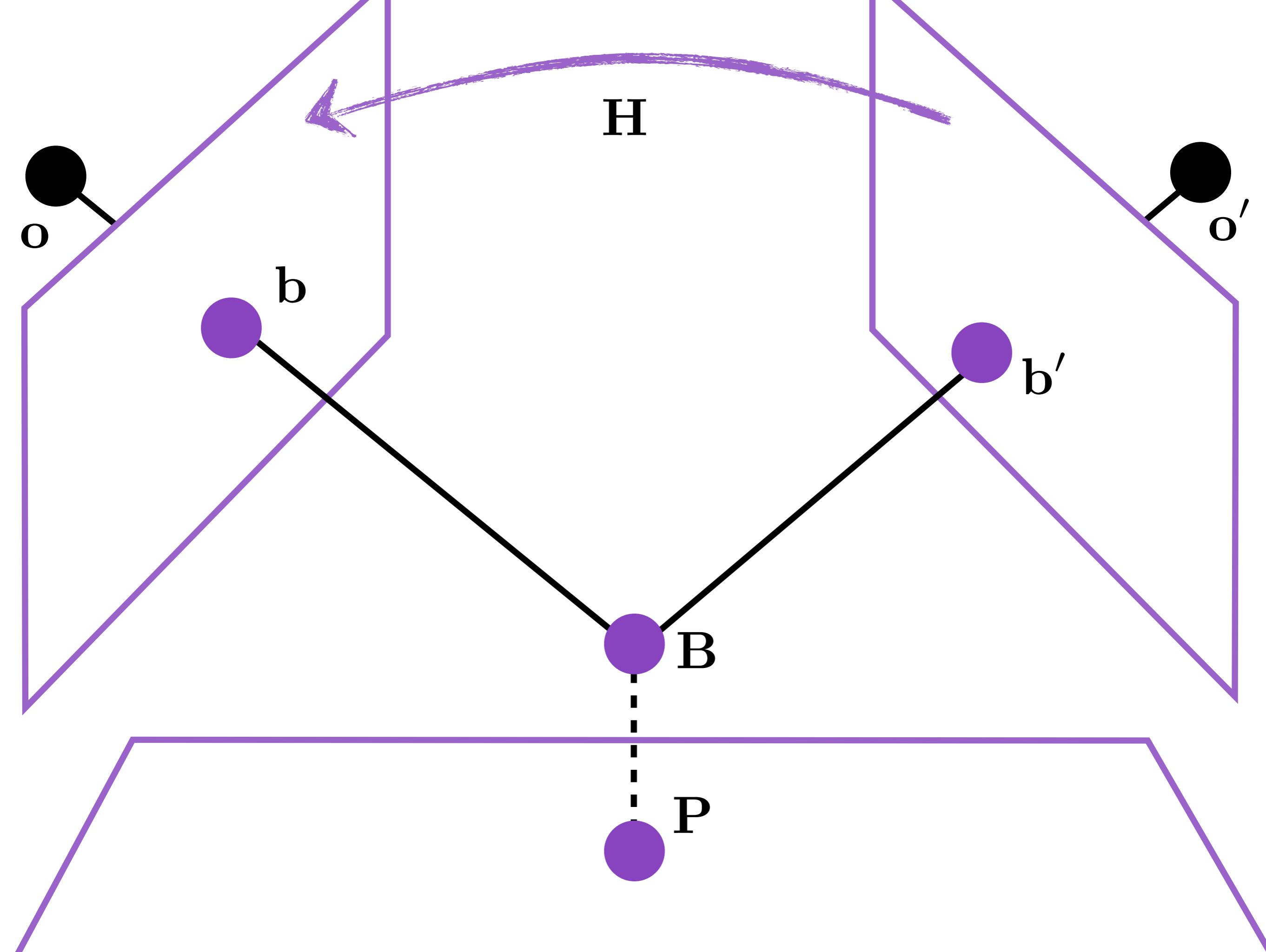
$$\frac{A'C'}{A'D'} : \frac{B'C'}{B'D'} = \frac{AC}{BC}$$



D' is the vertical vanishing point

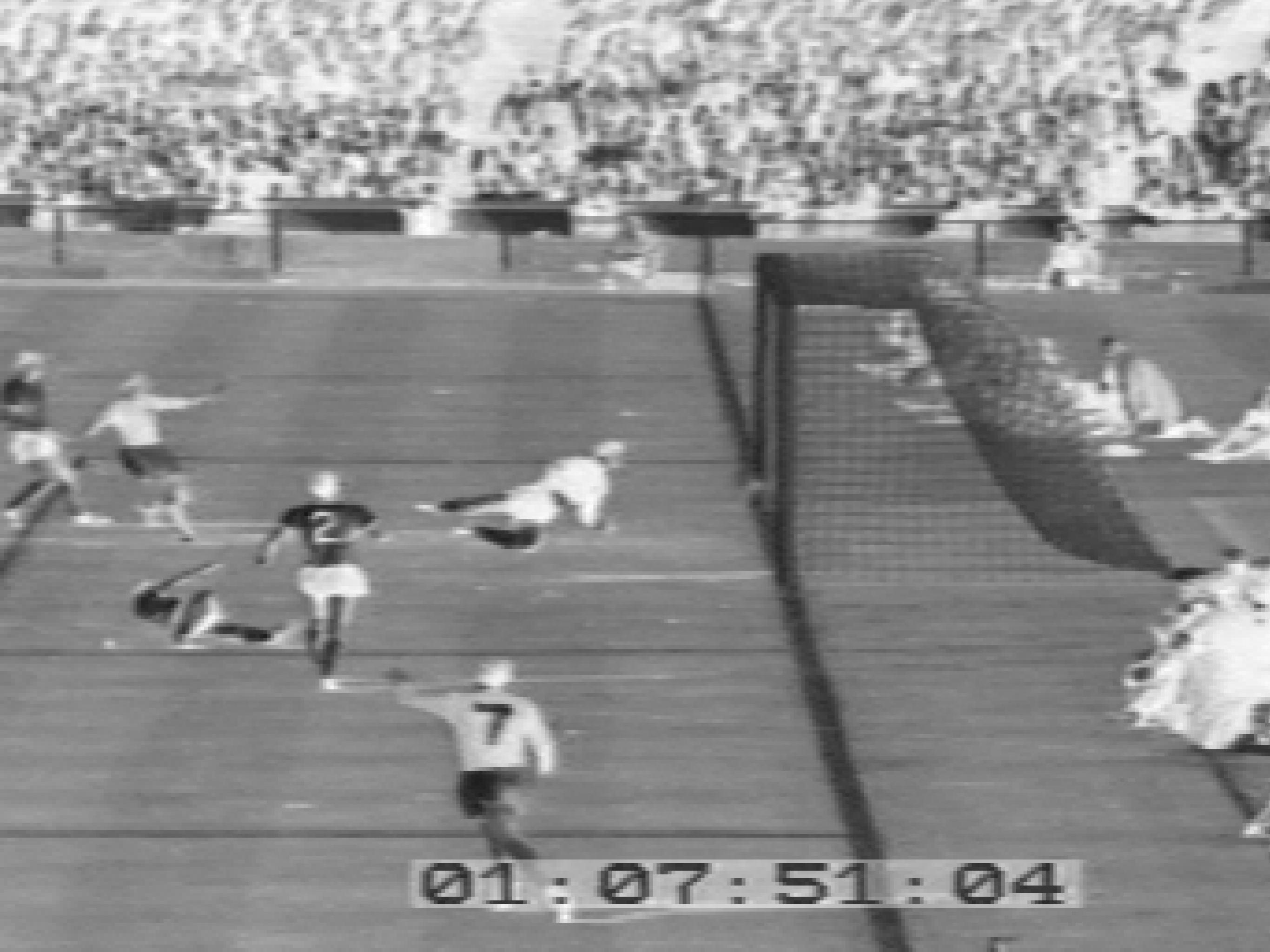
$$\frac{A'C'}{A'D'} : \frac{B'C'}{B'D'} = \frac{AC}{BC}$$

To find AB, solve for BC and subtract from AC

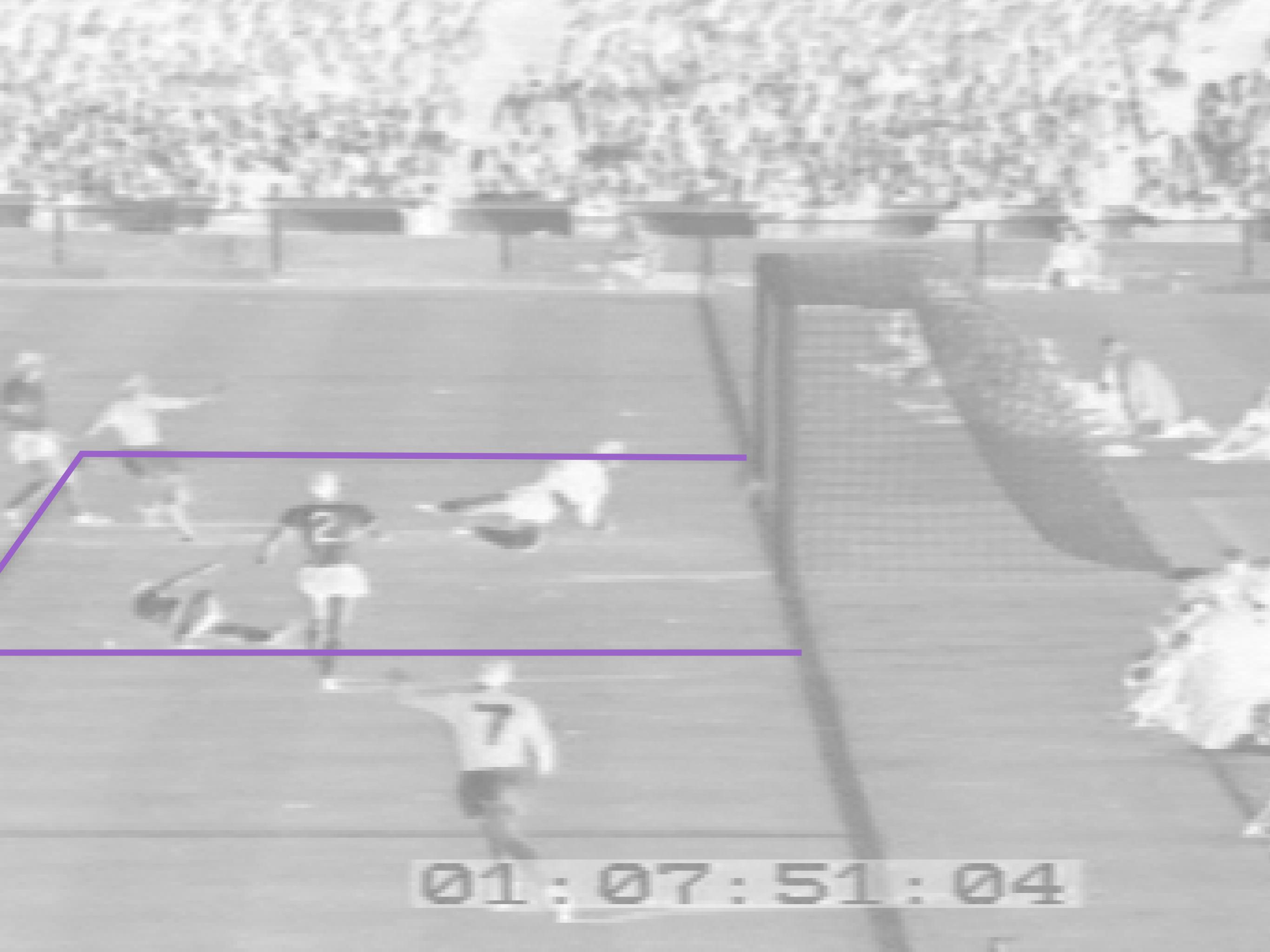




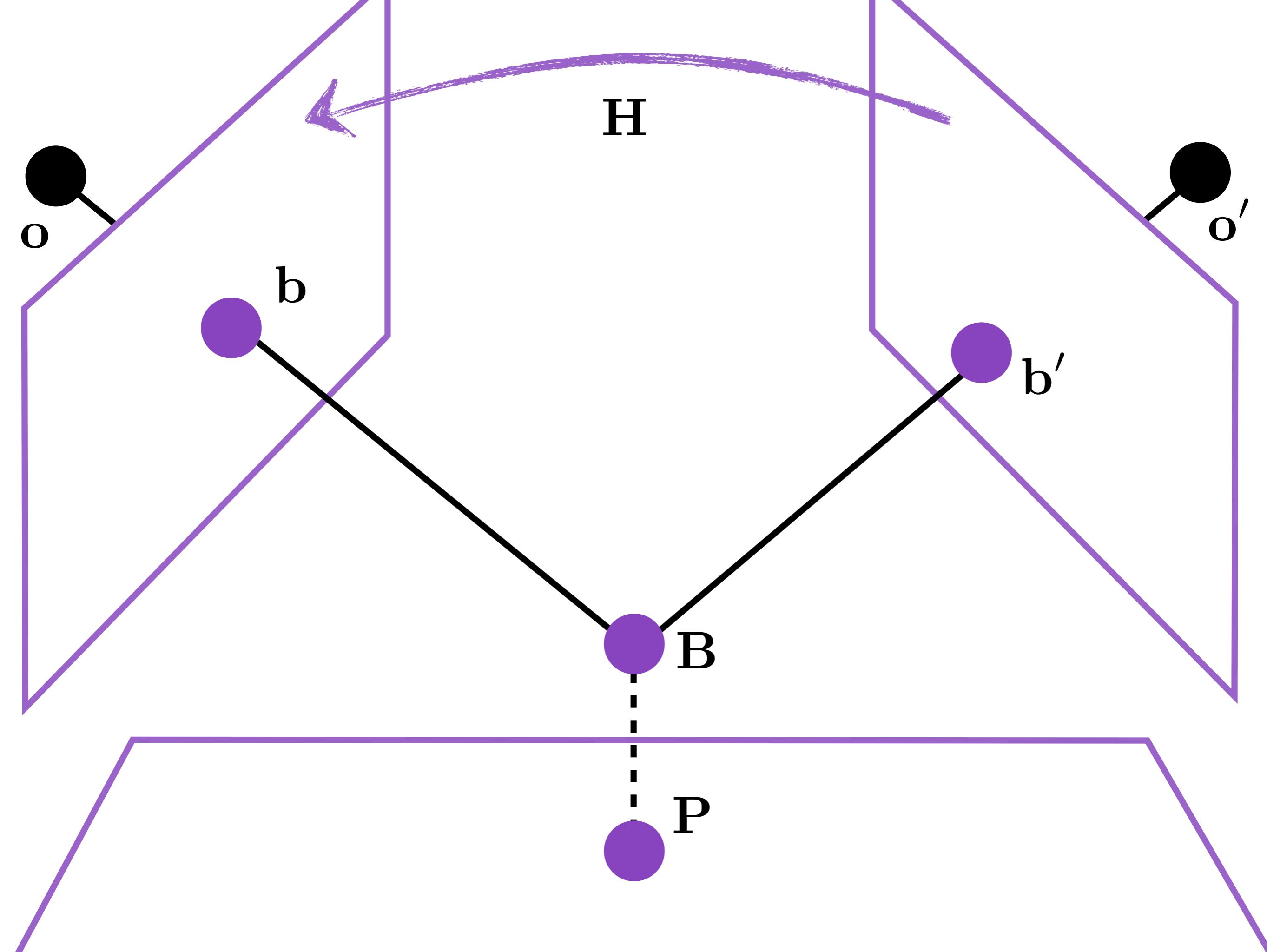
01:07:30:21

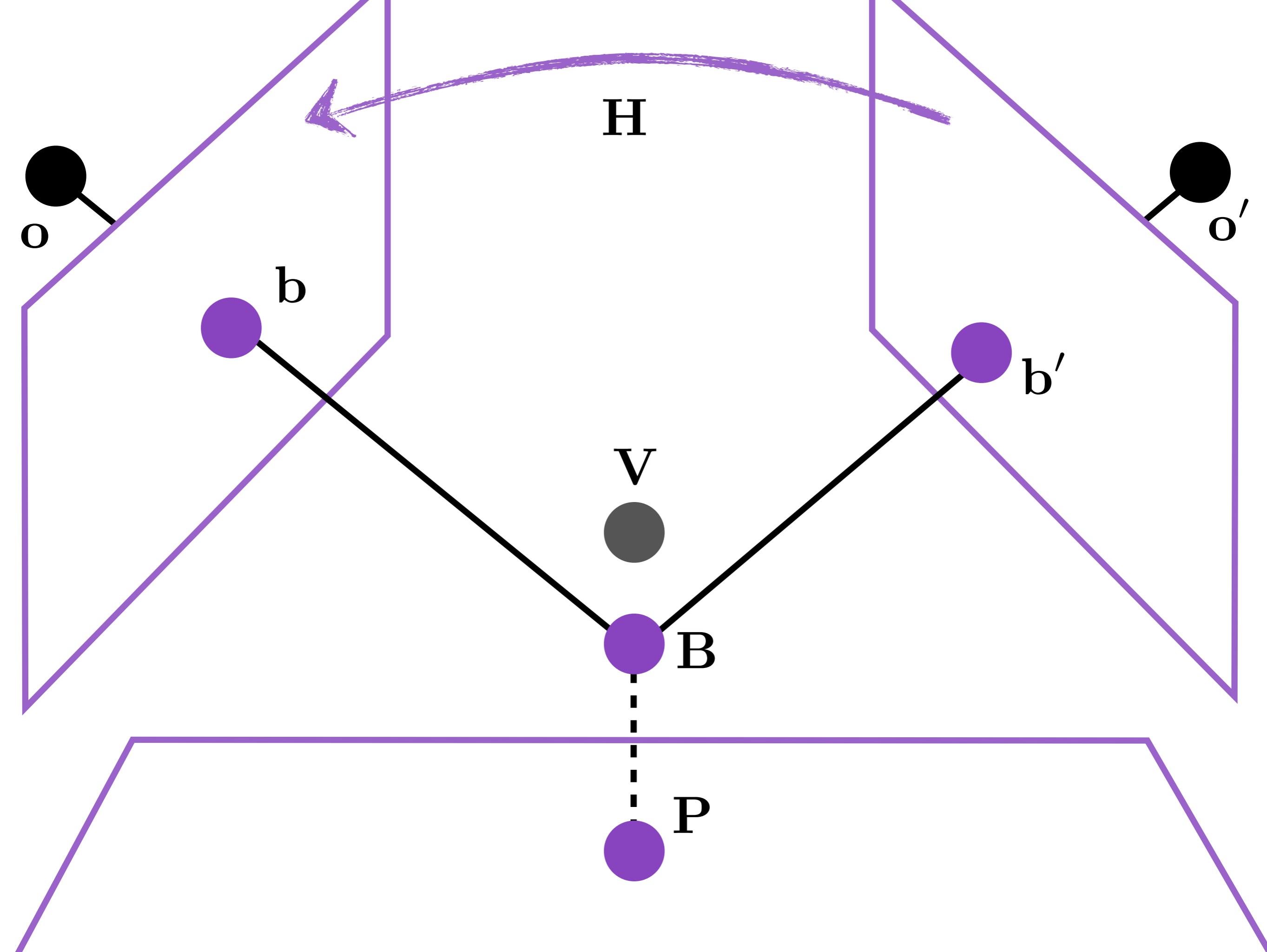


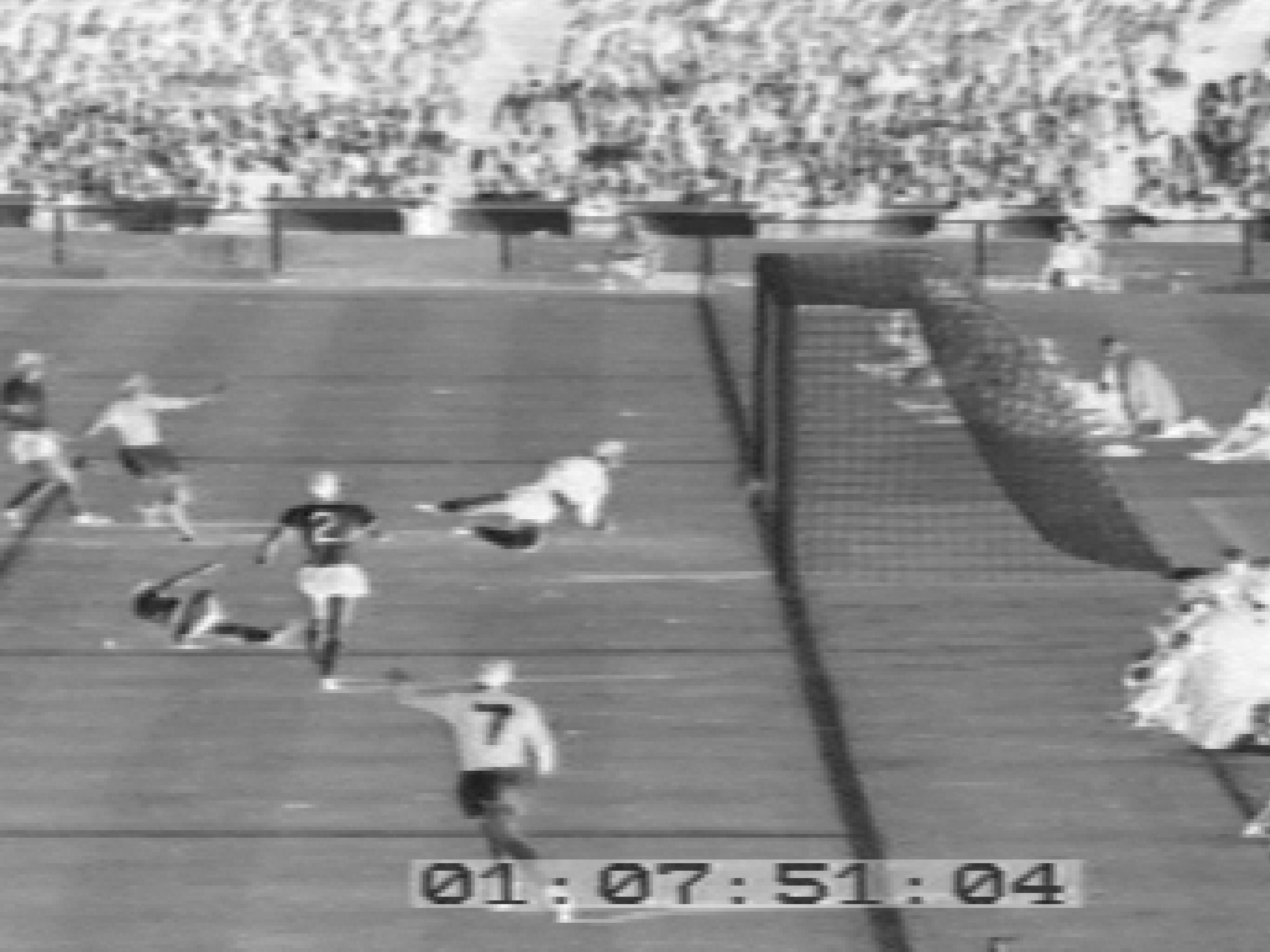
01:07:51:04



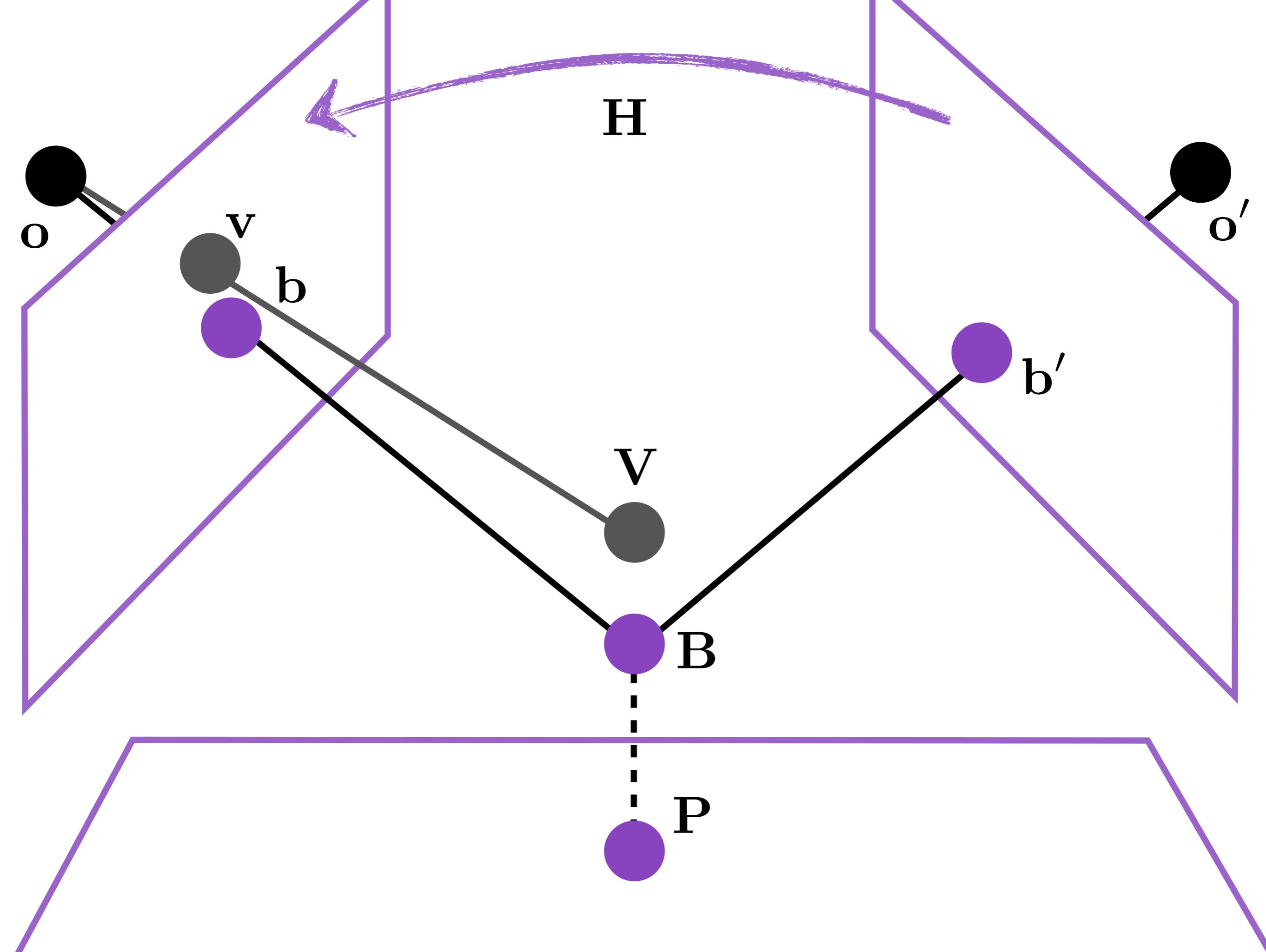
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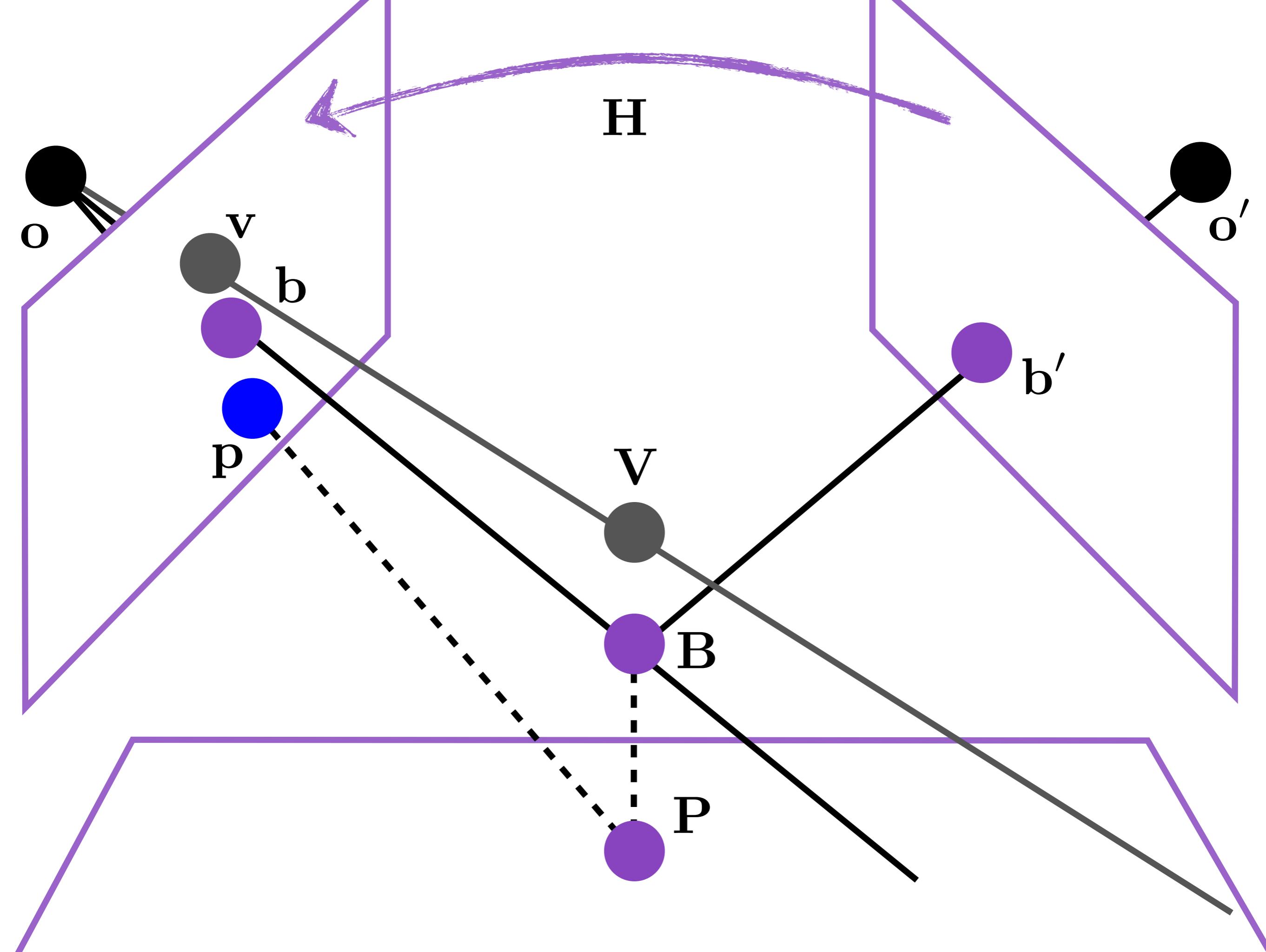


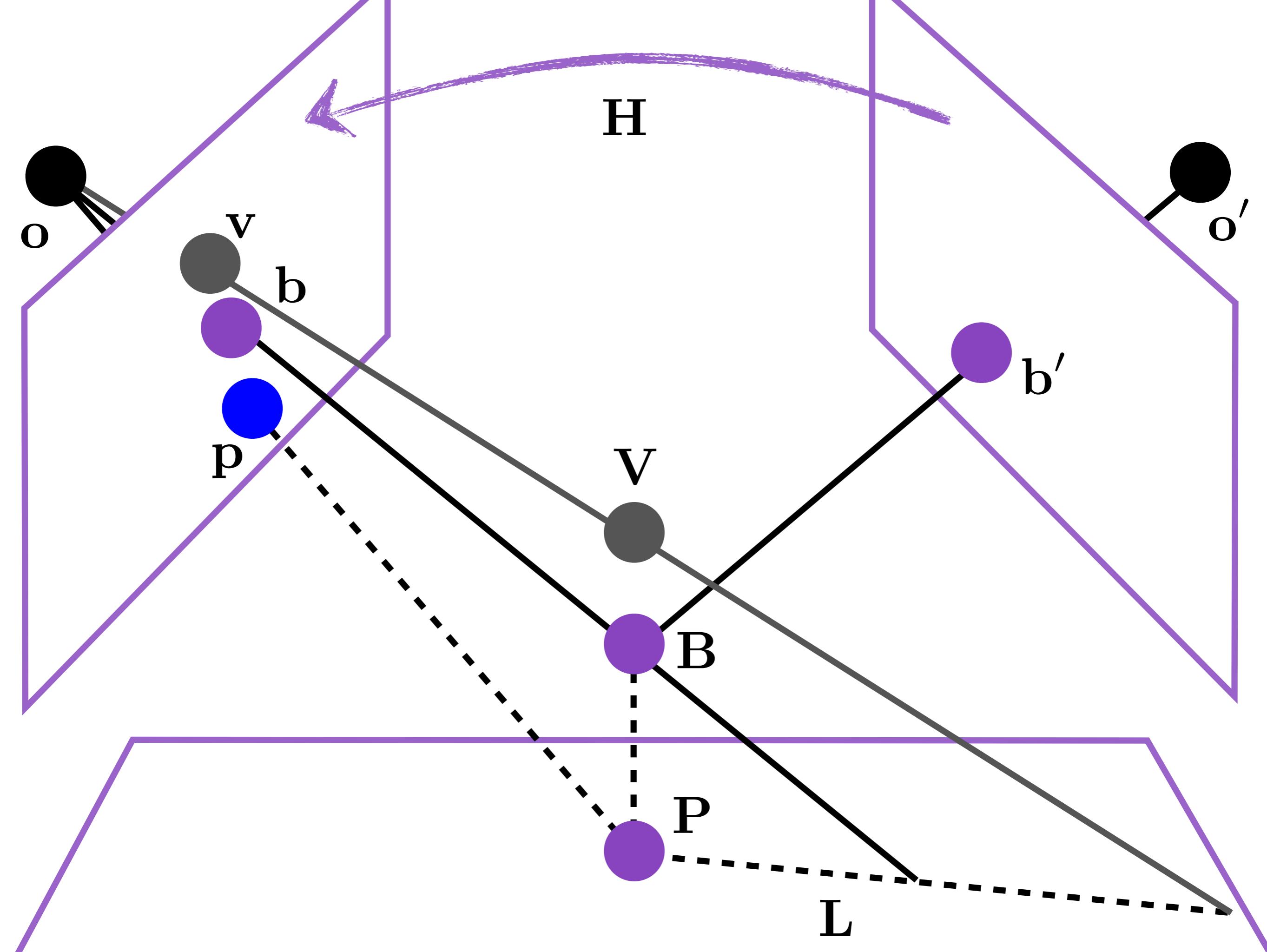


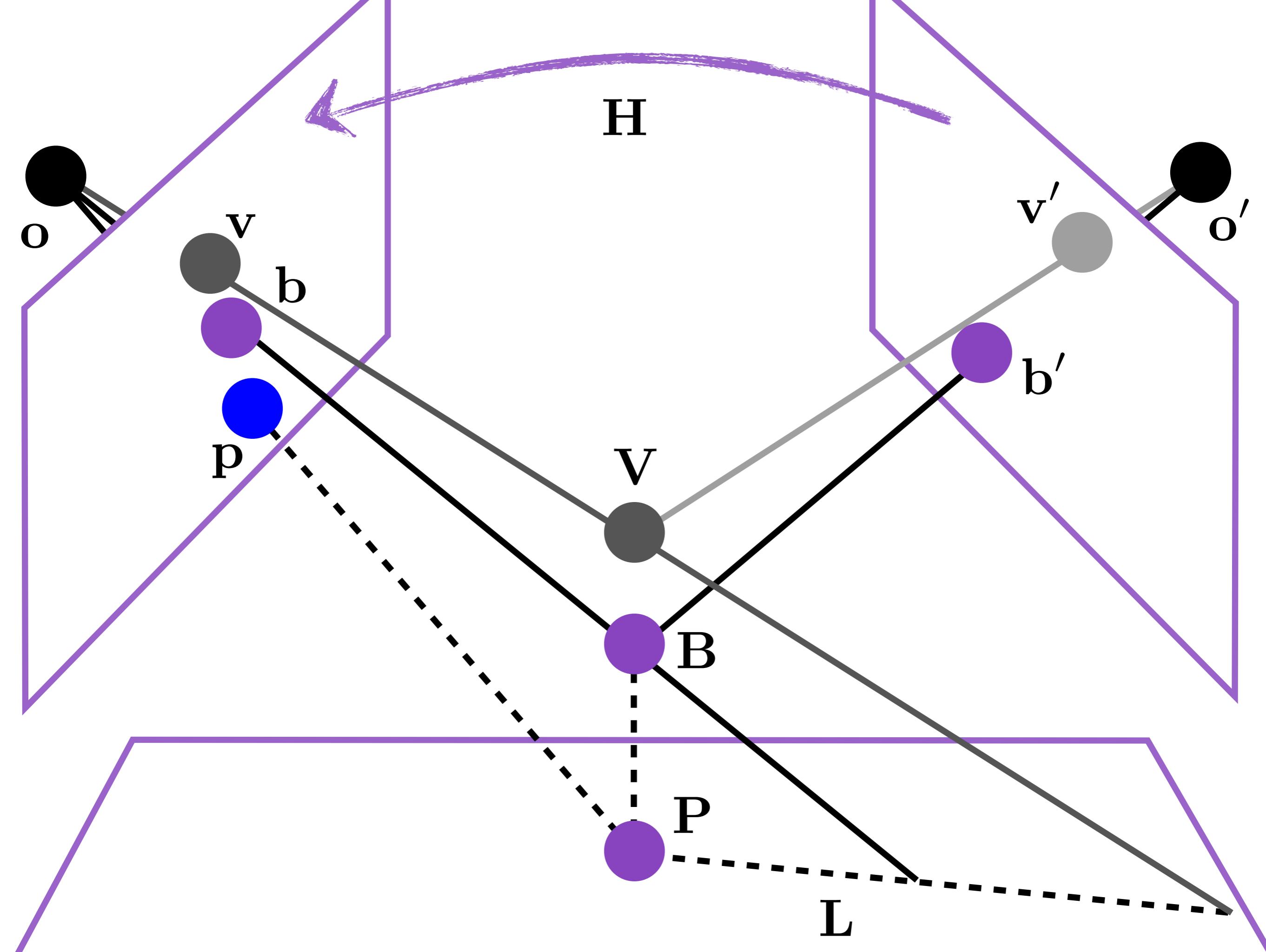


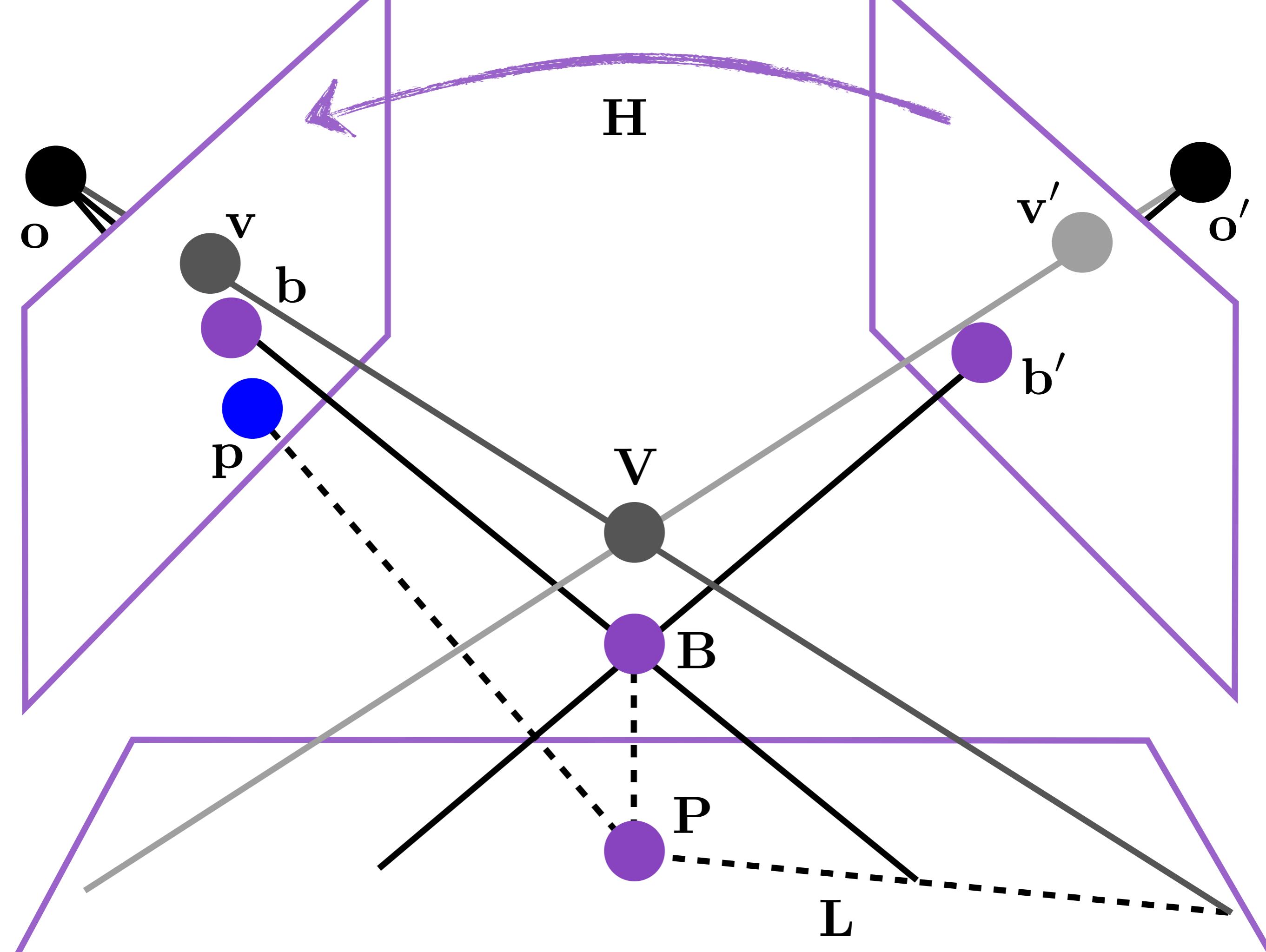
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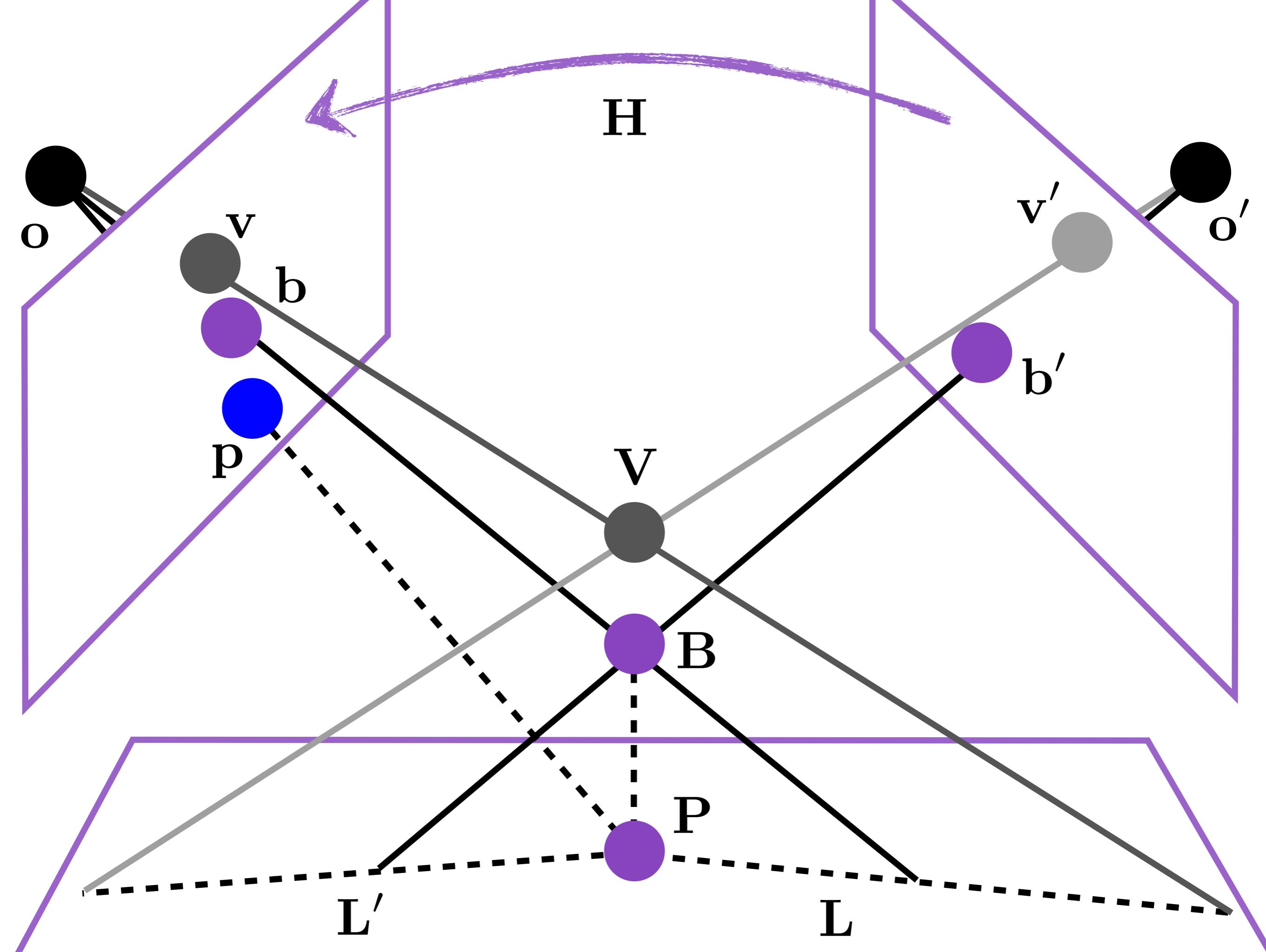


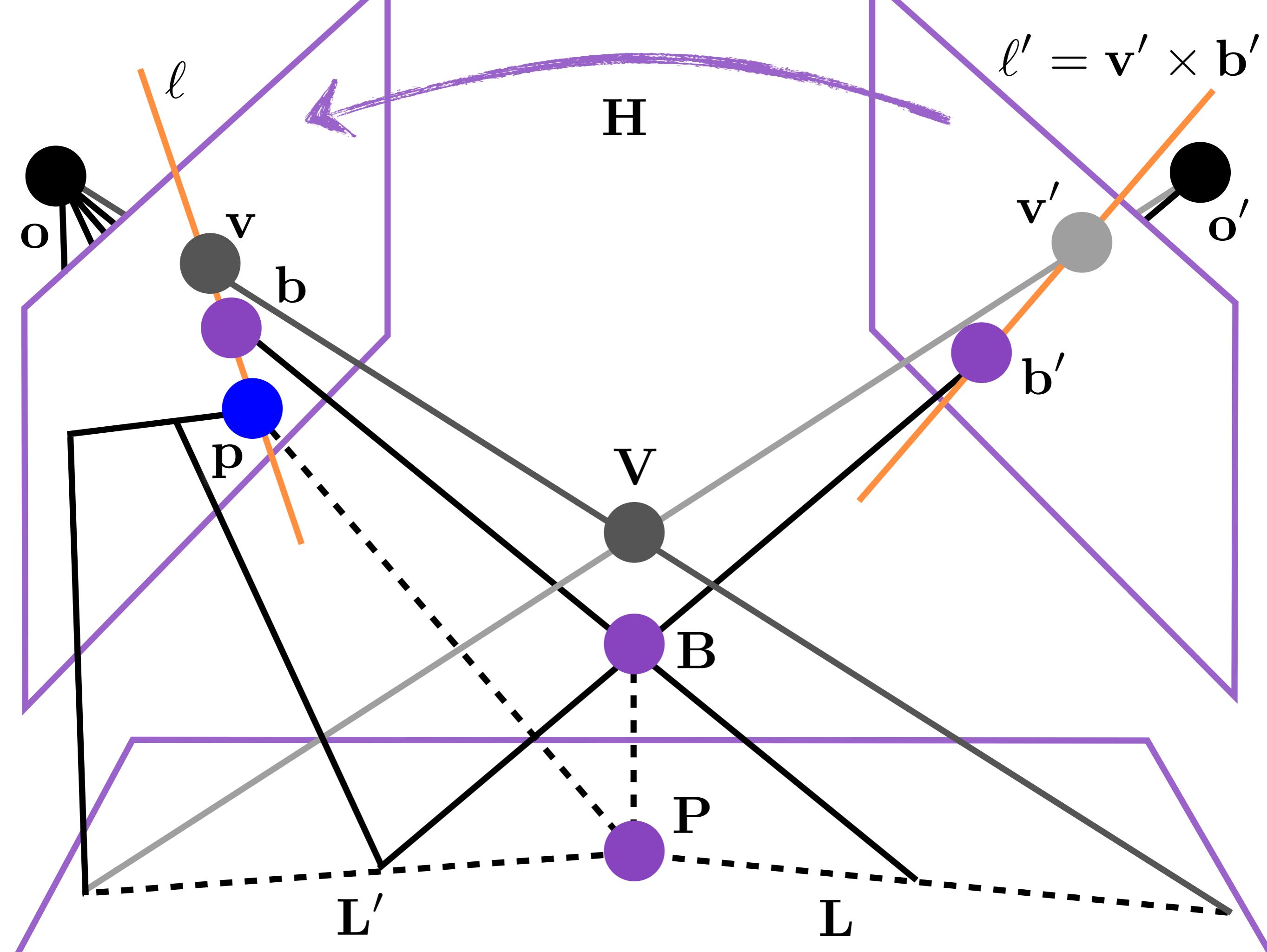


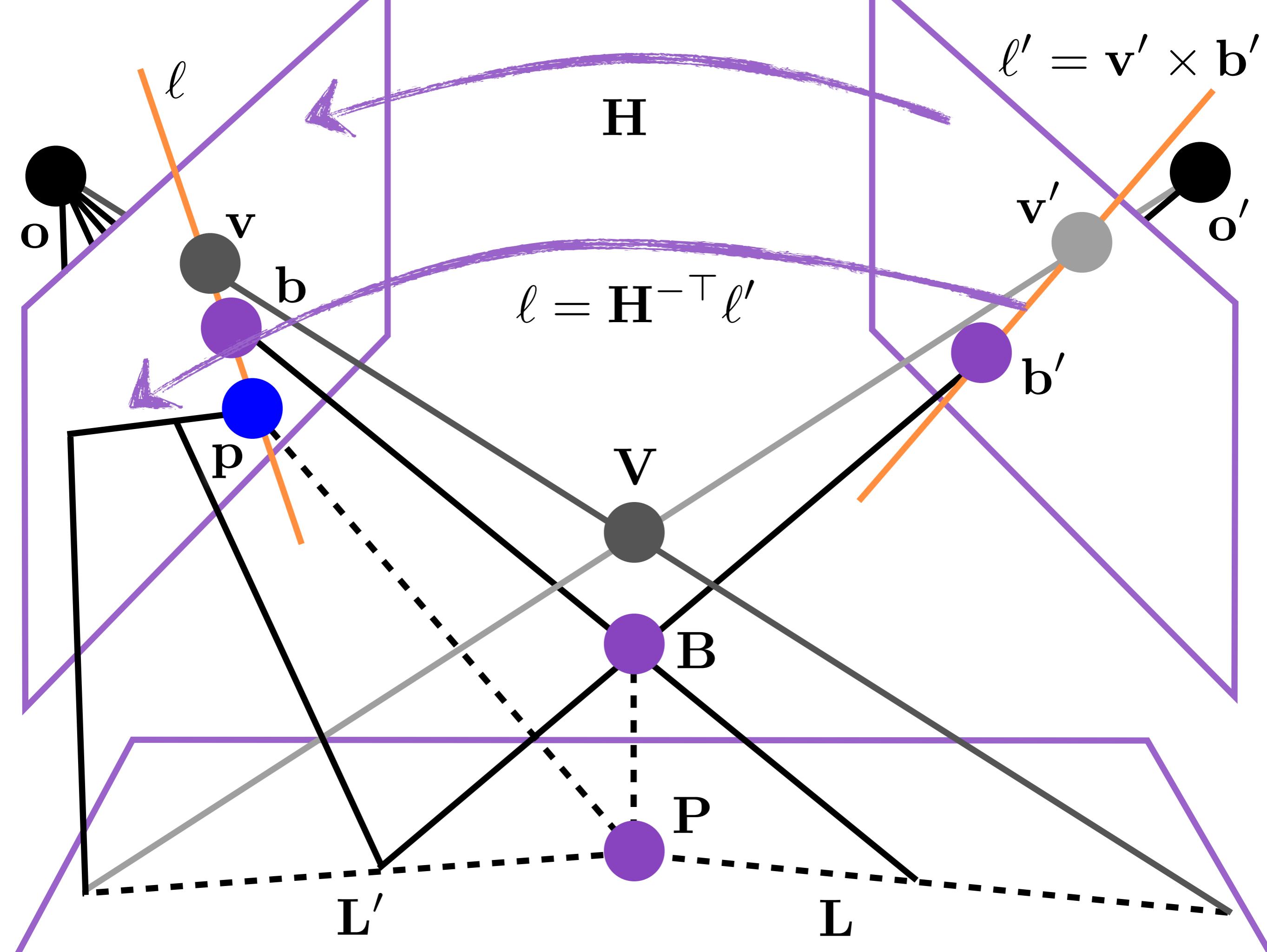


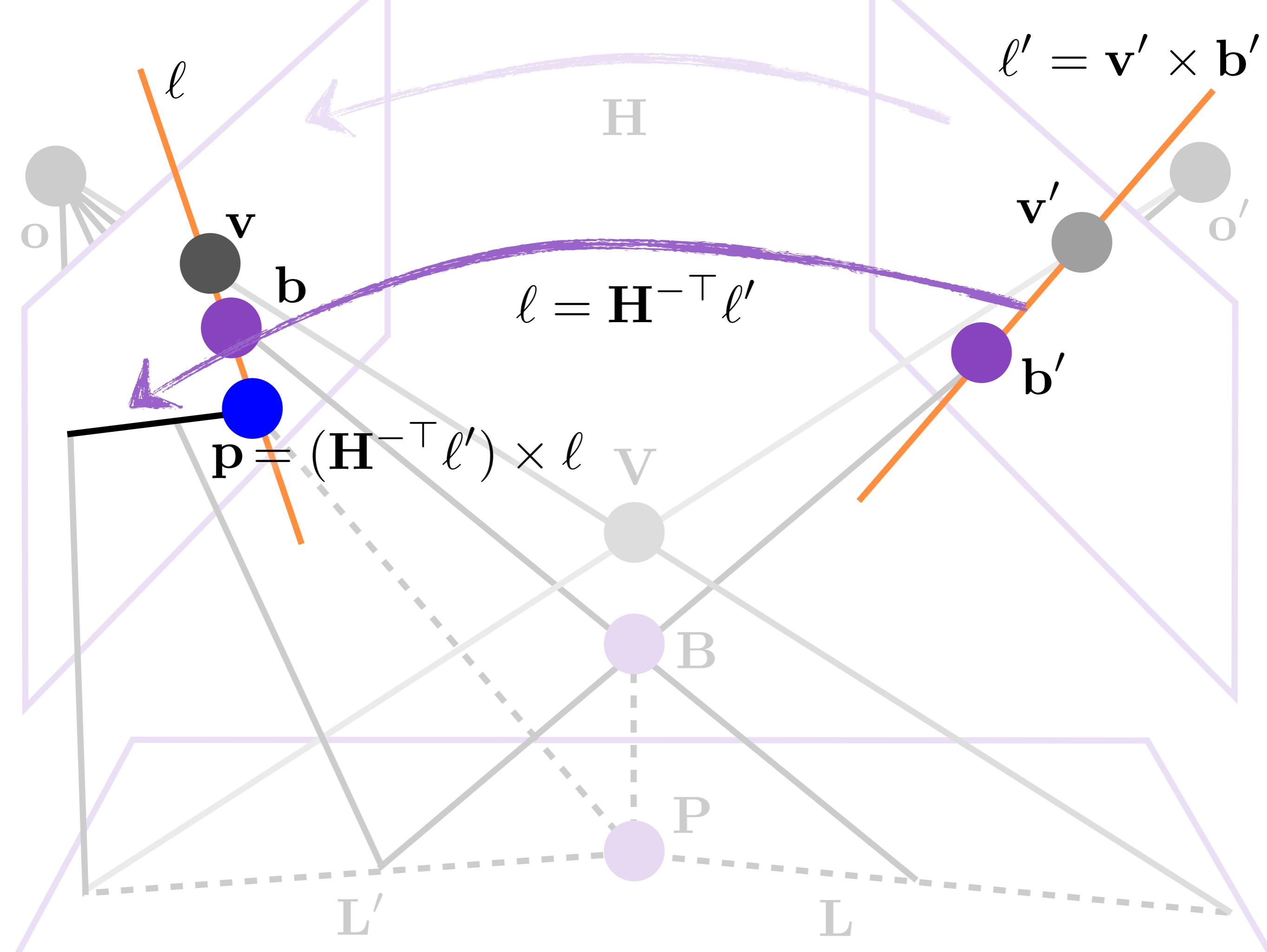




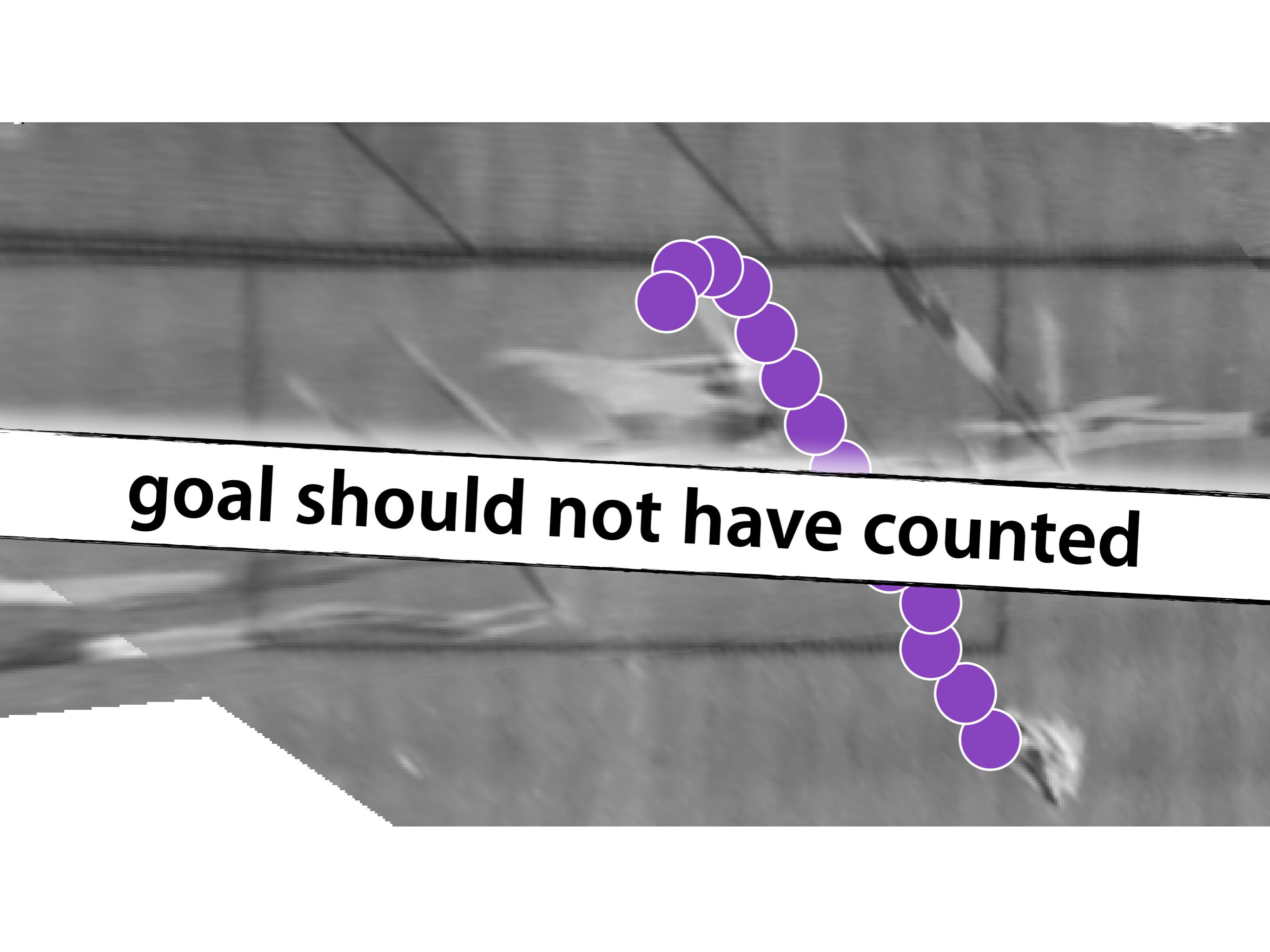








**ball did not fully cross the line**



**goal should not have counted**