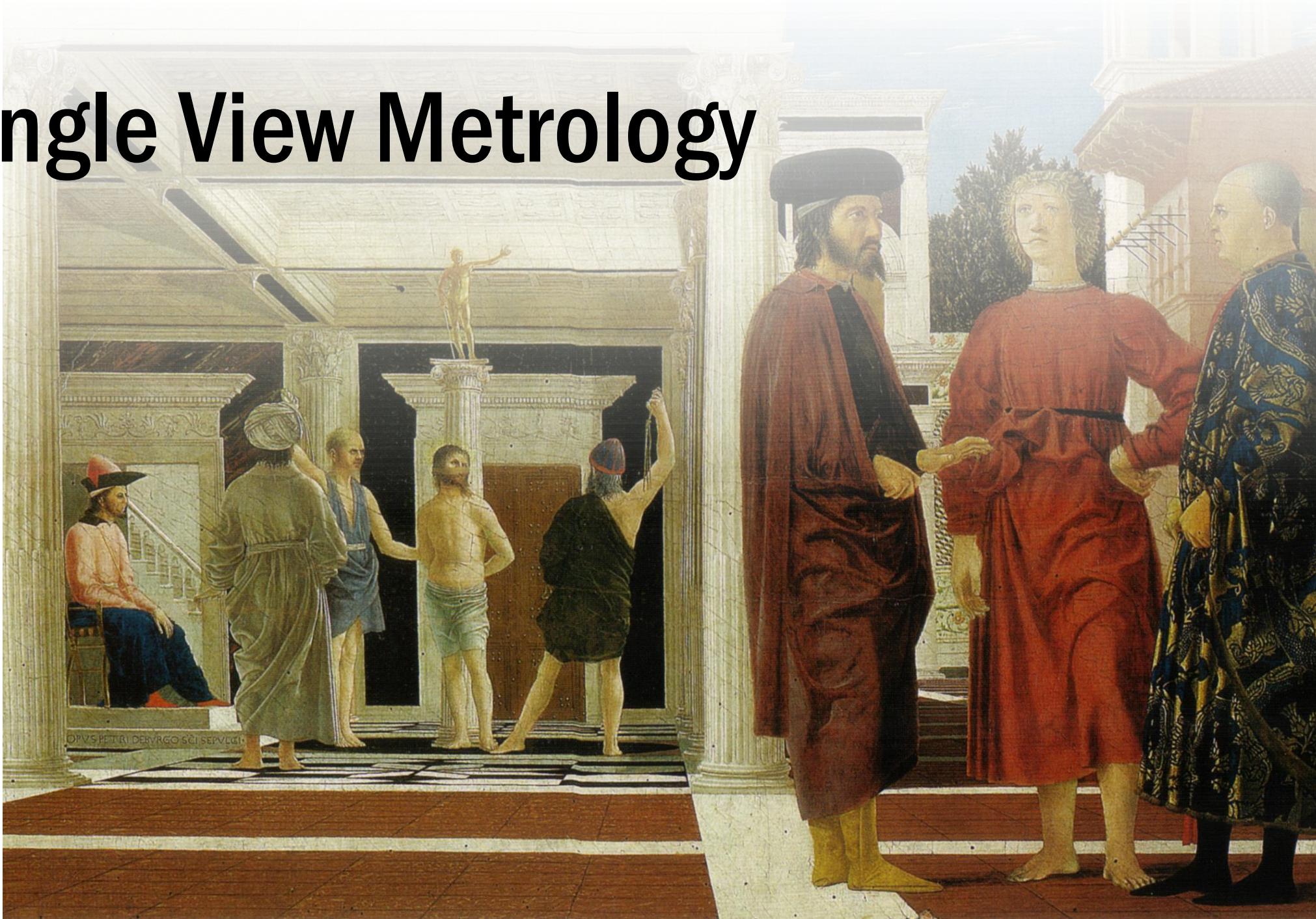


Single View Metrology





Criminisi et al. "Single View Geometry", IC



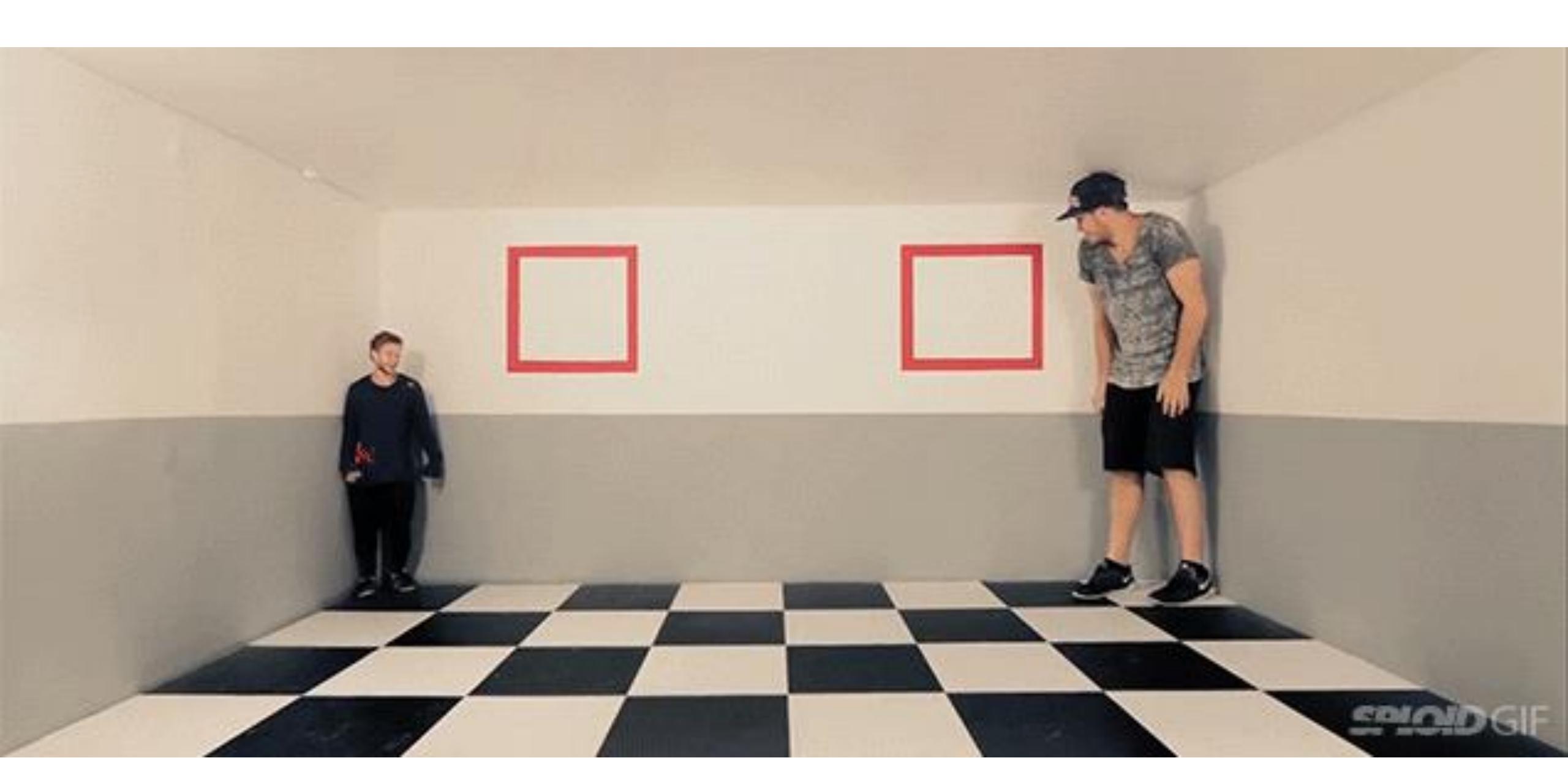
Criminisi et al. "Single View Geometry", ICCV



Criminisi et al. "Single View Geometry", IC

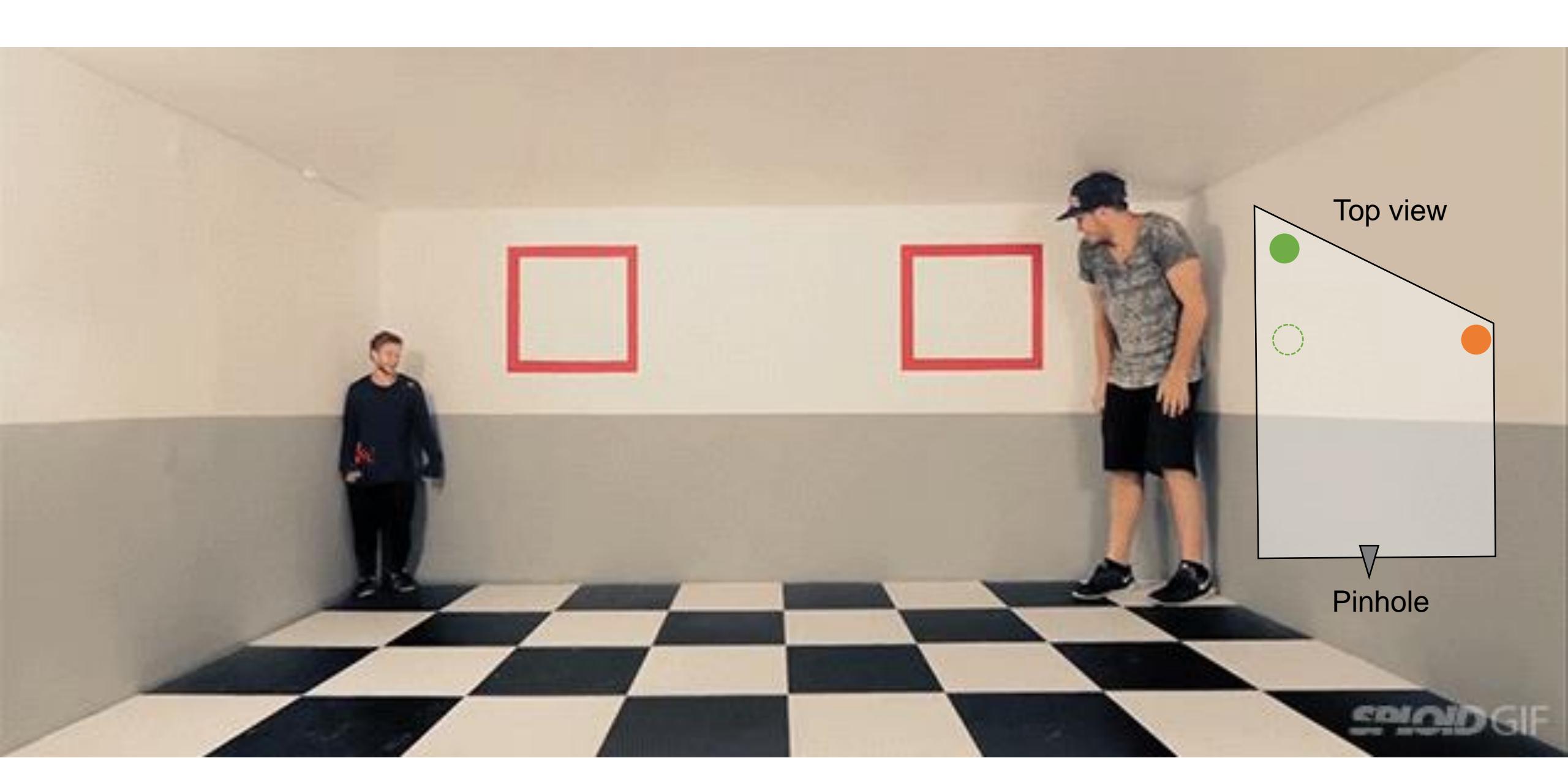


Hoiem et al. "Automatic Photo Pop-up", SIGGRAPH



solidGIF

Ames roo



Ames roo

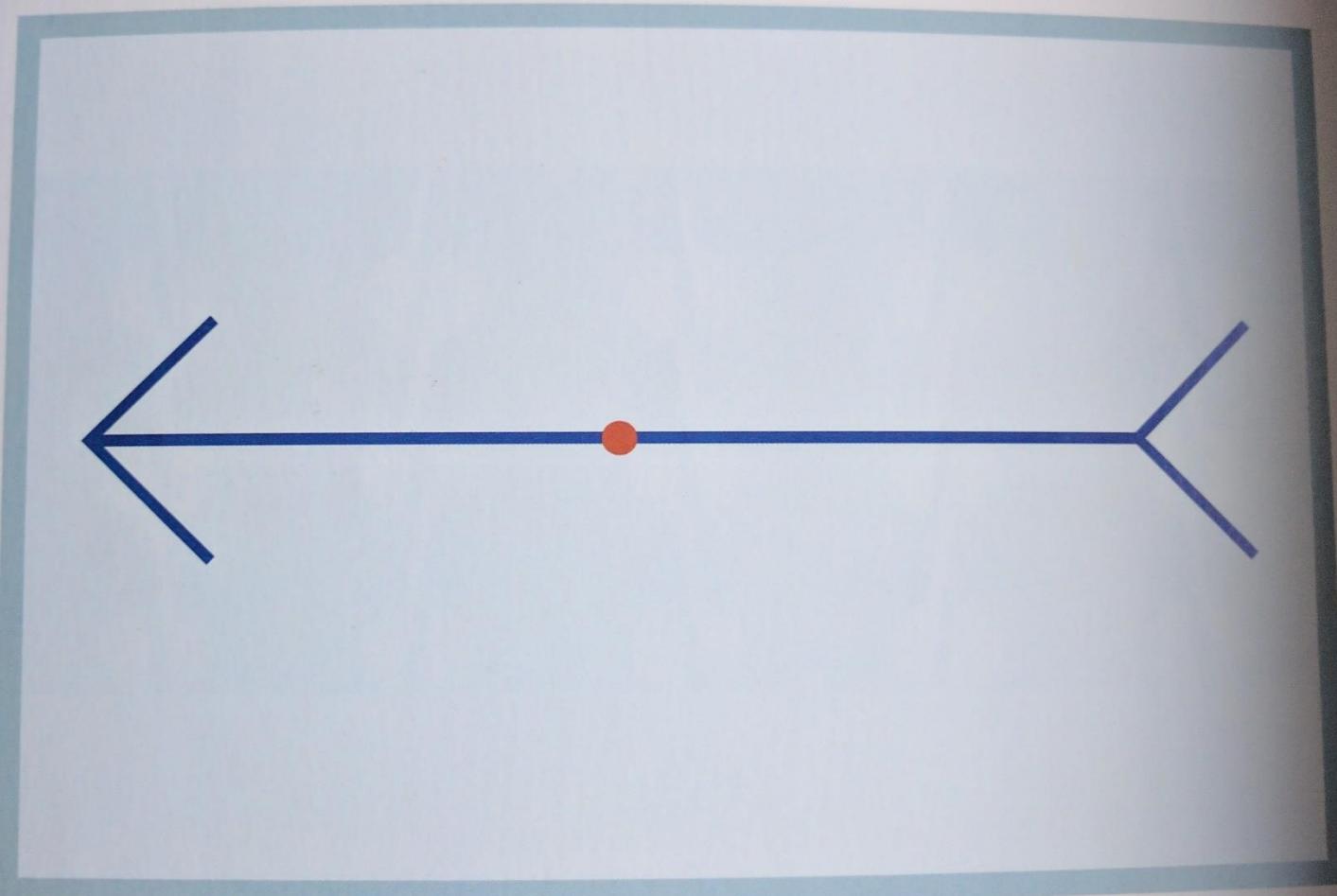
MLPS-St. Paul International A

Vanishing line

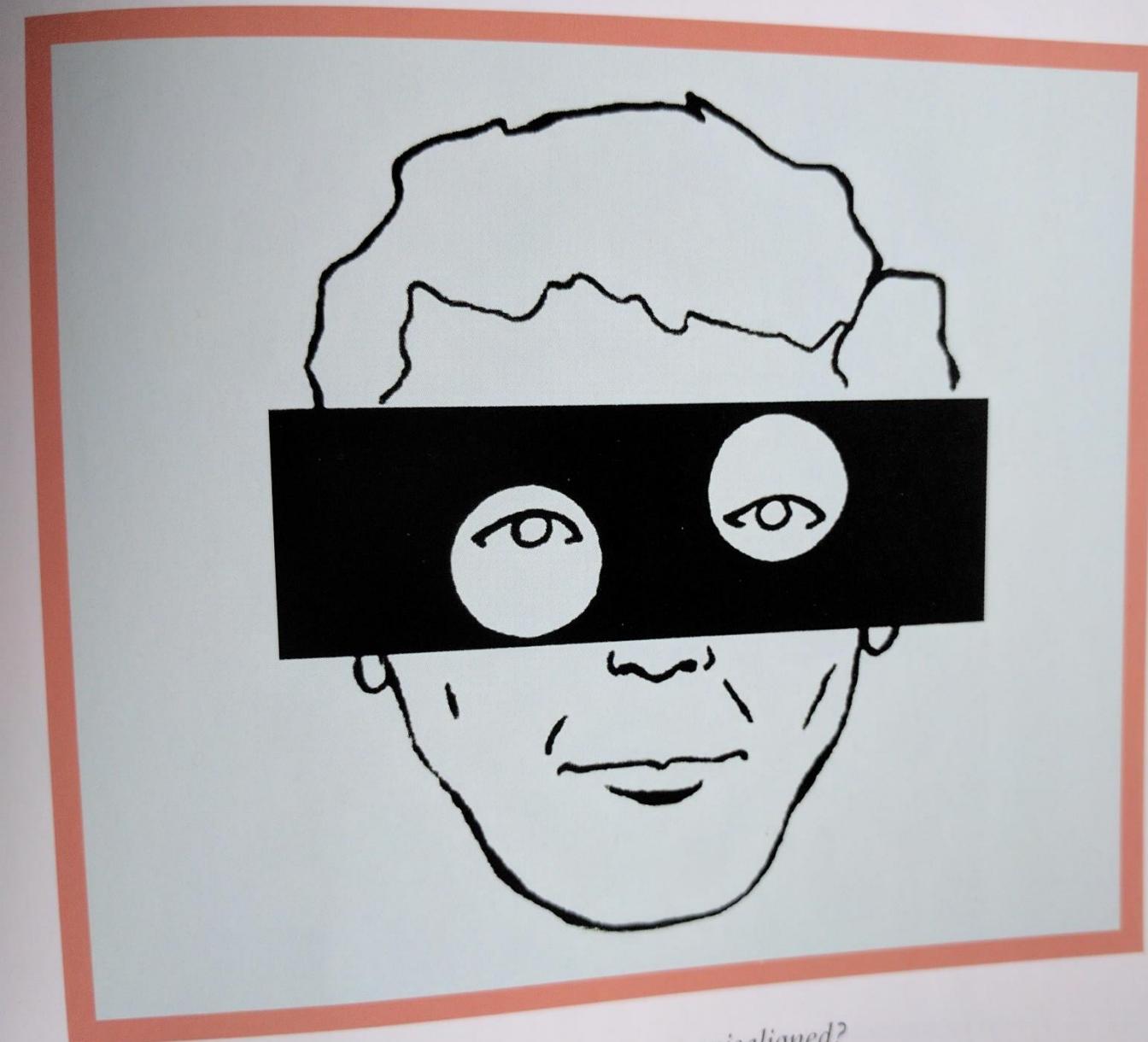
Distance cannot be trusted.



The Judd Illusion

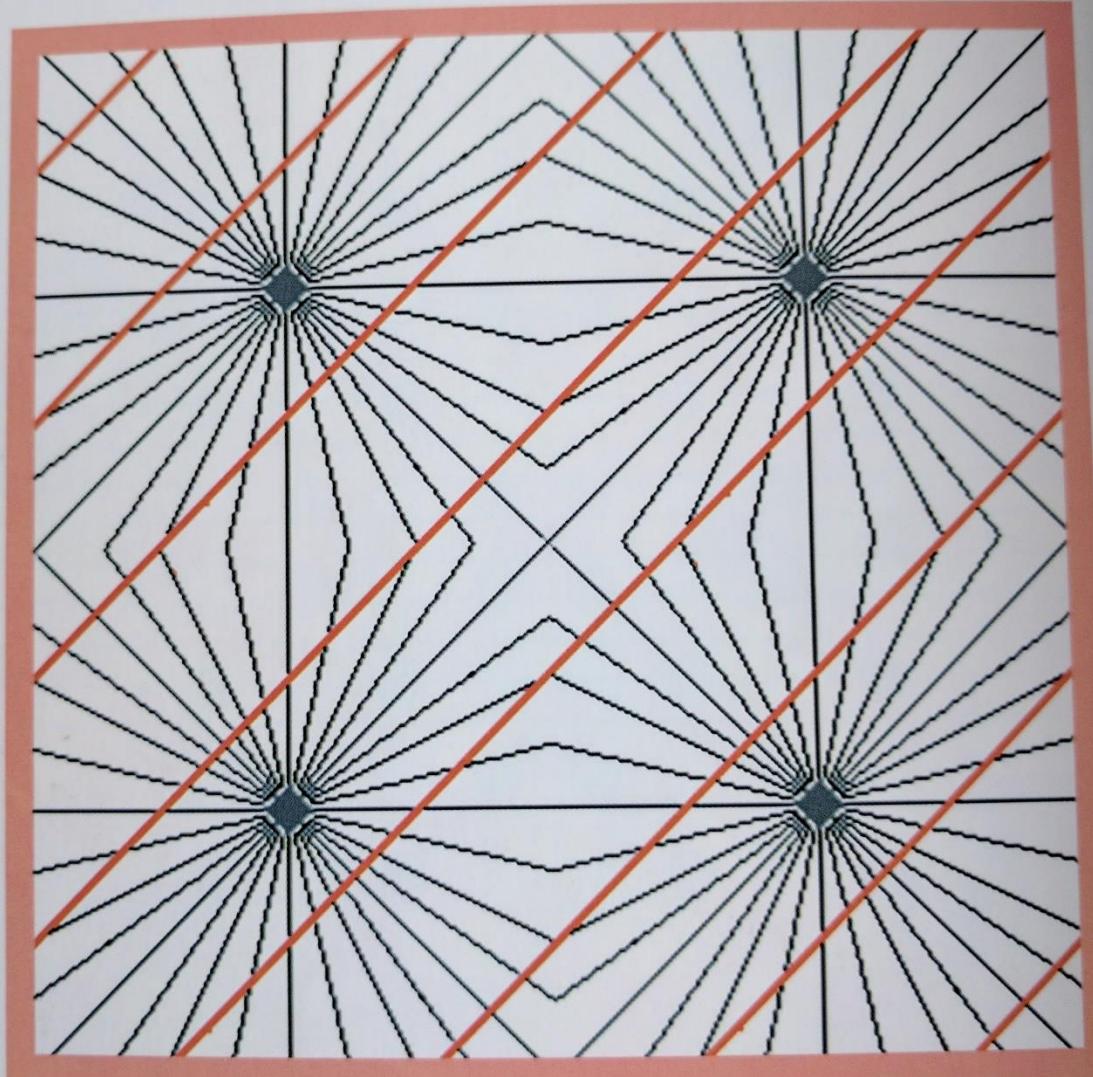


*Does the red dot appear to be in the middle of the arrow?
Check your answer with a ruler.*



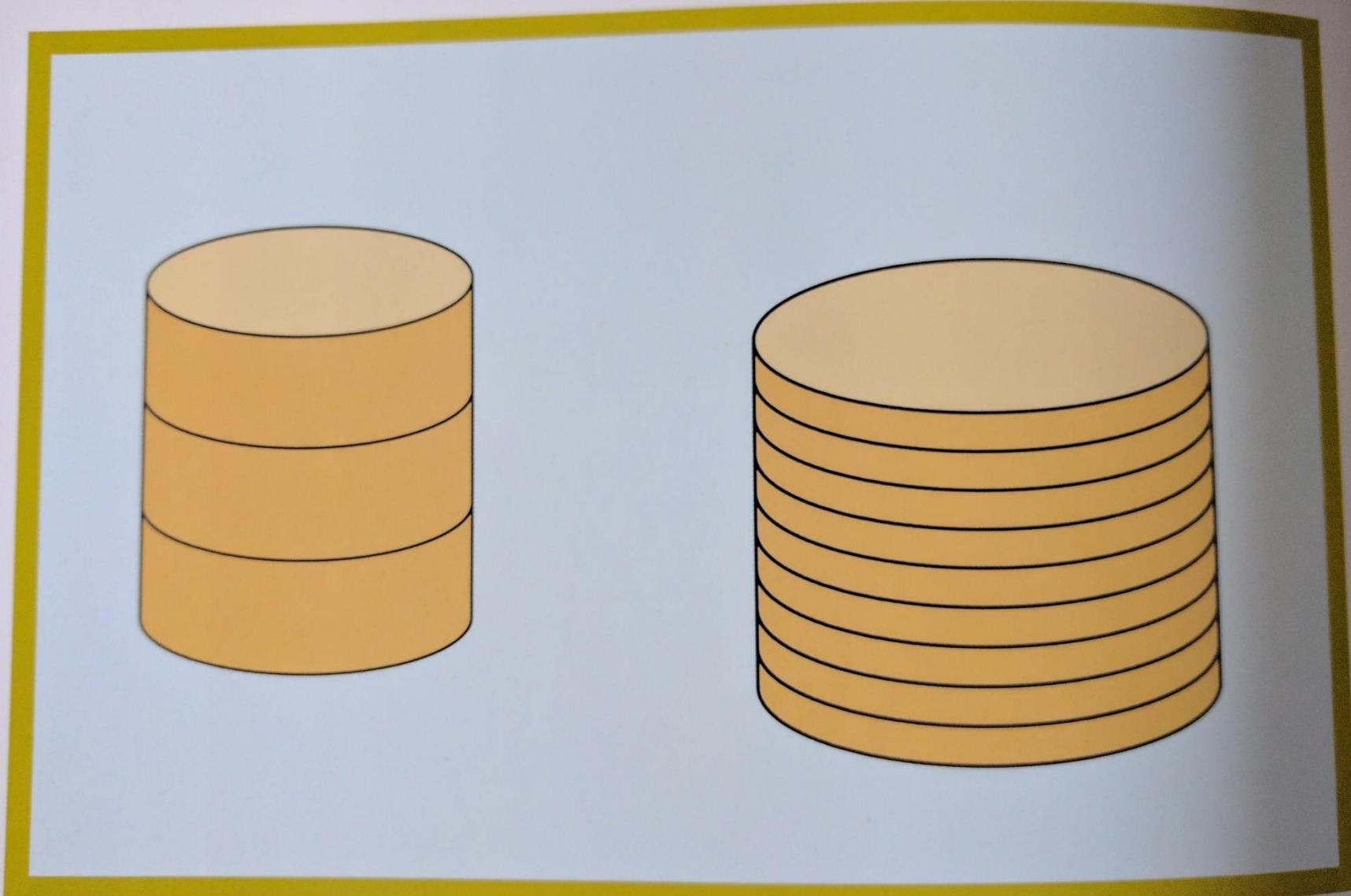
Do the eyes appear misaligned?

Straight Lines?



*Are the red lines straight and parallel?
Check your answer with a straightedge.*

Stack of Coins Illusion



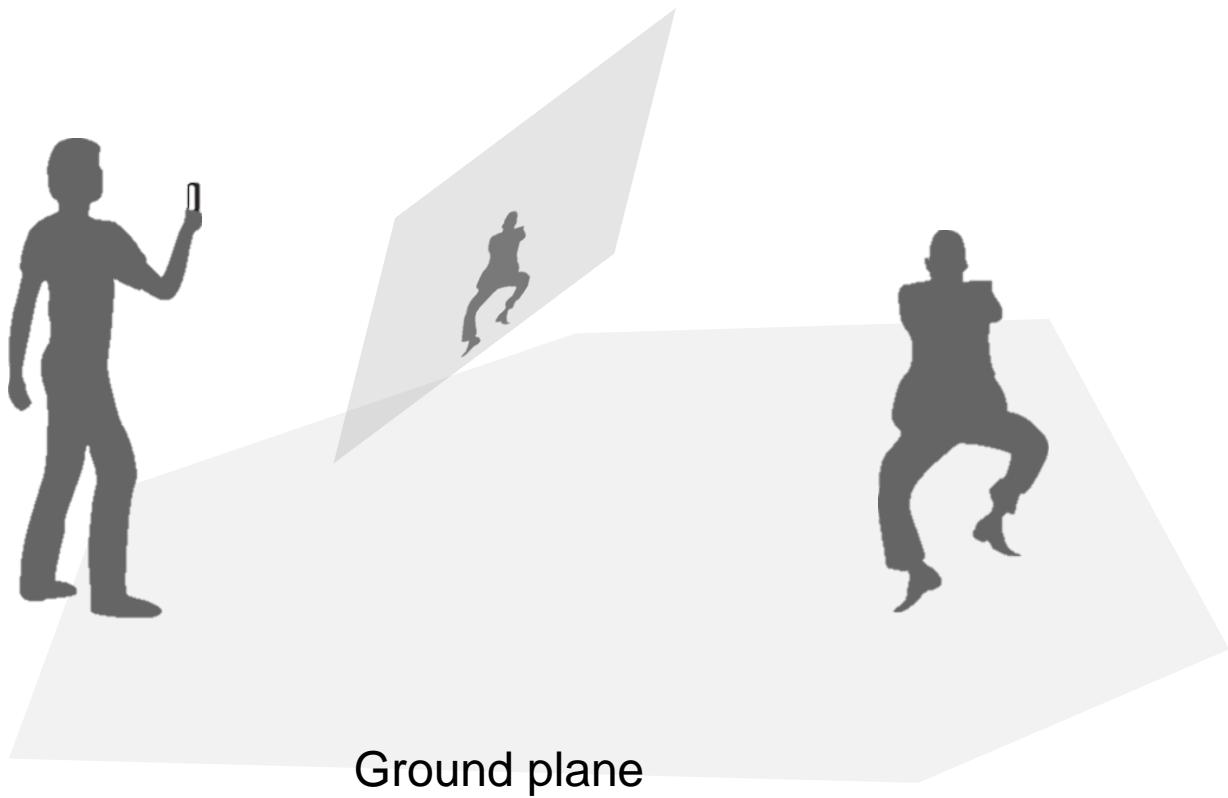
Which stack of coins is higher?

The Plank Illusion

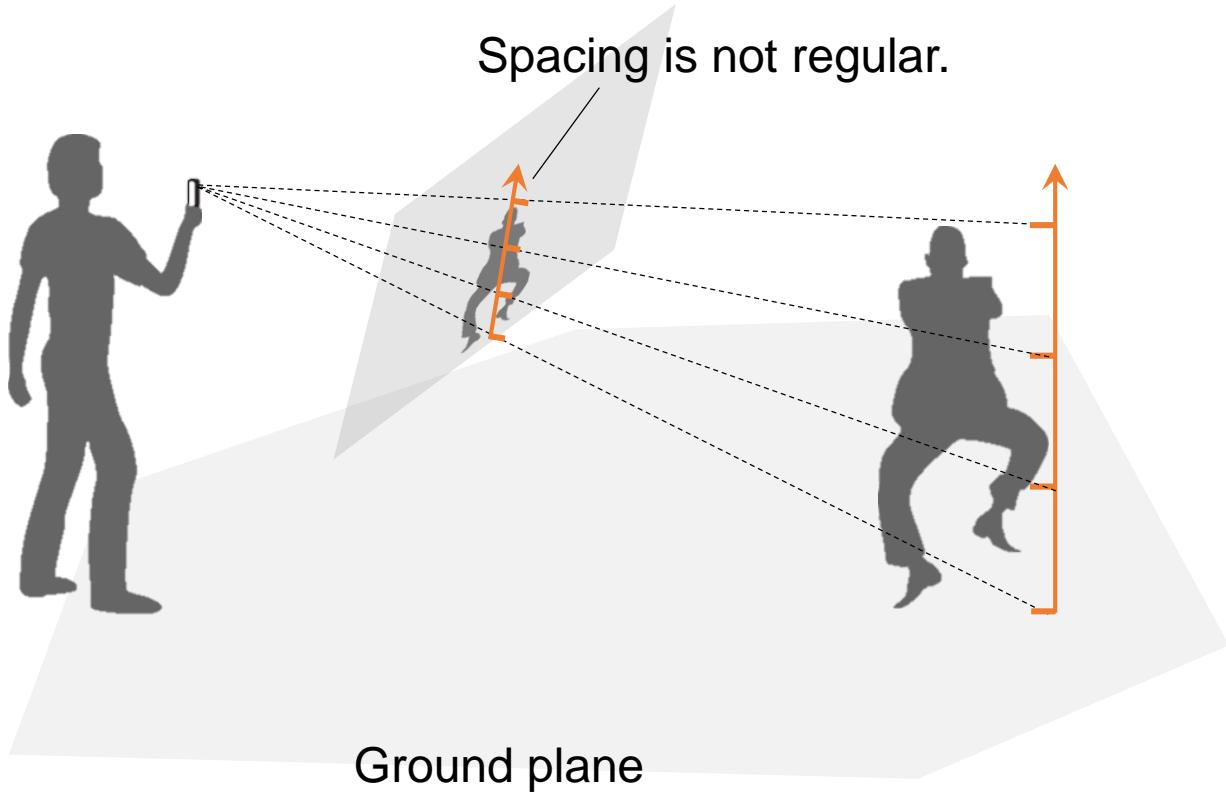


These two men appear to change in height, although all they have done is change exact places on a level plank.

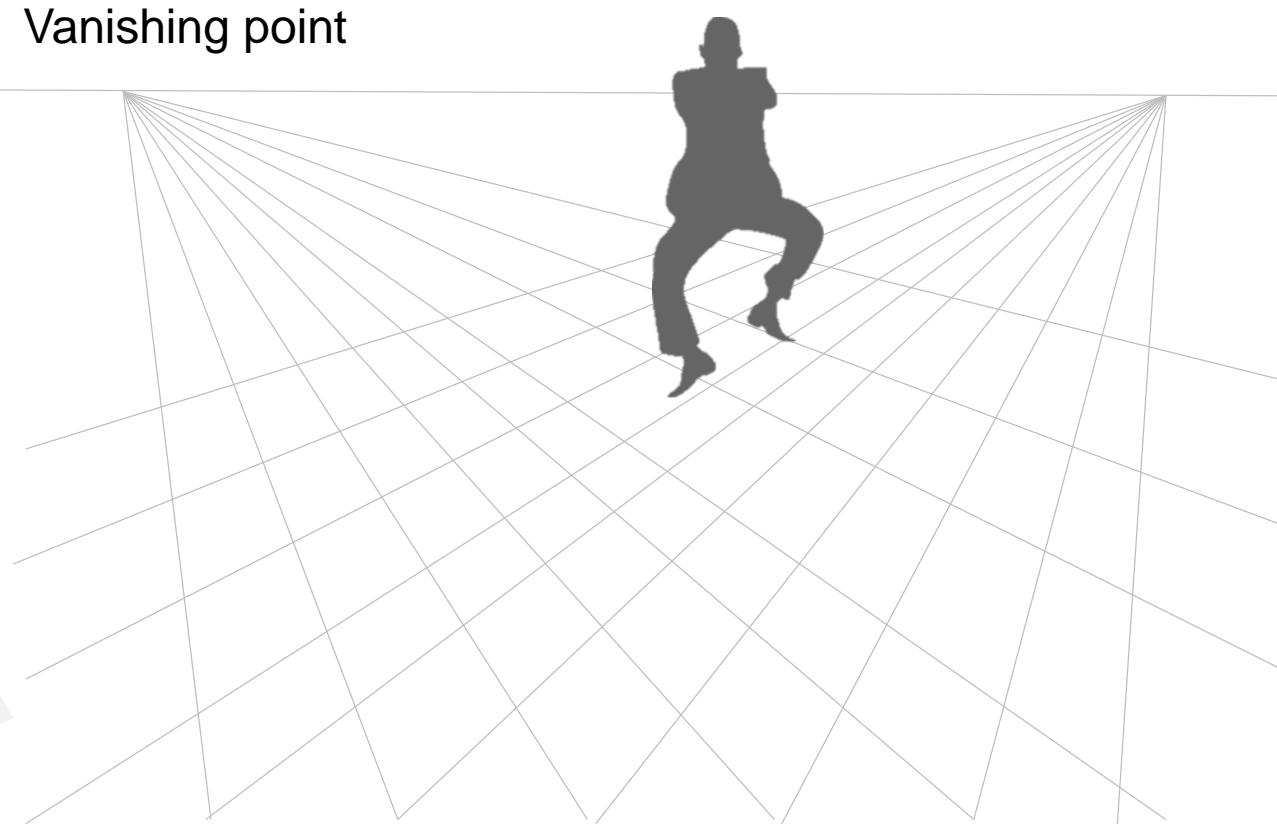
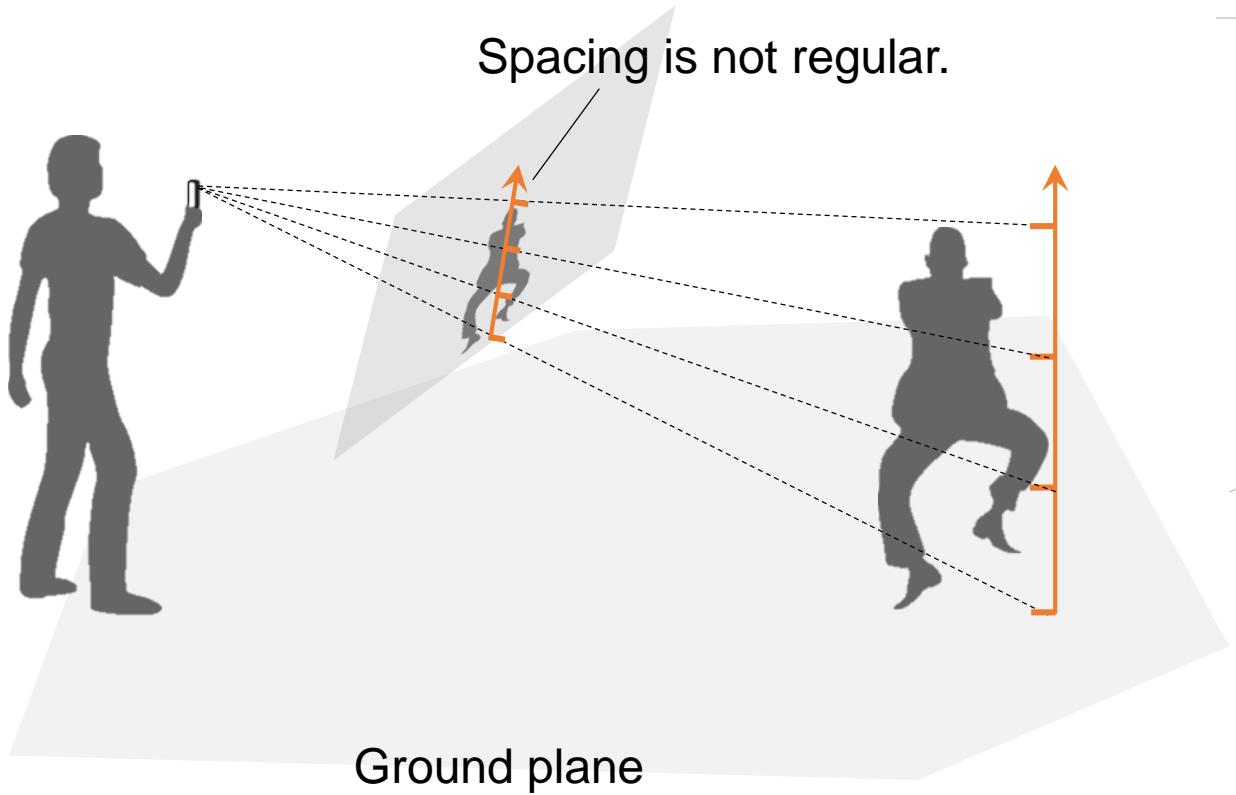
Height from Image



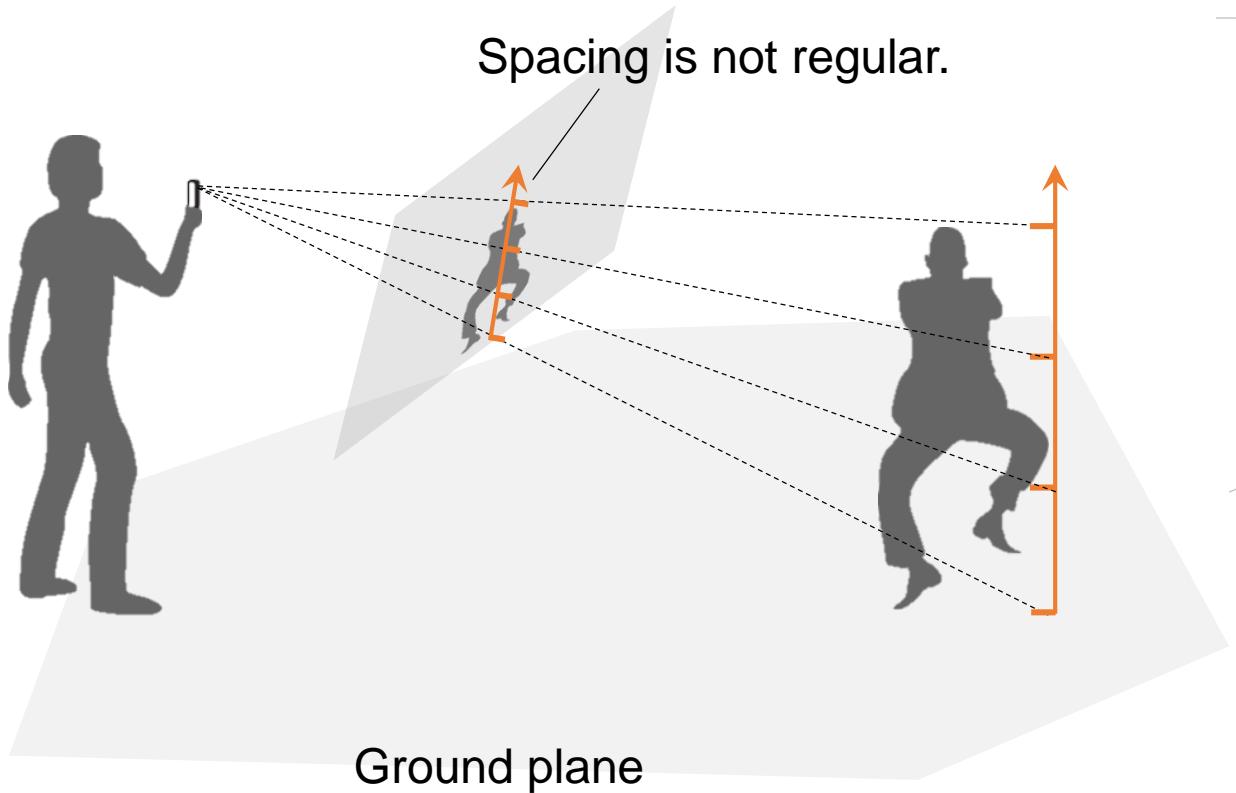
Height from Image



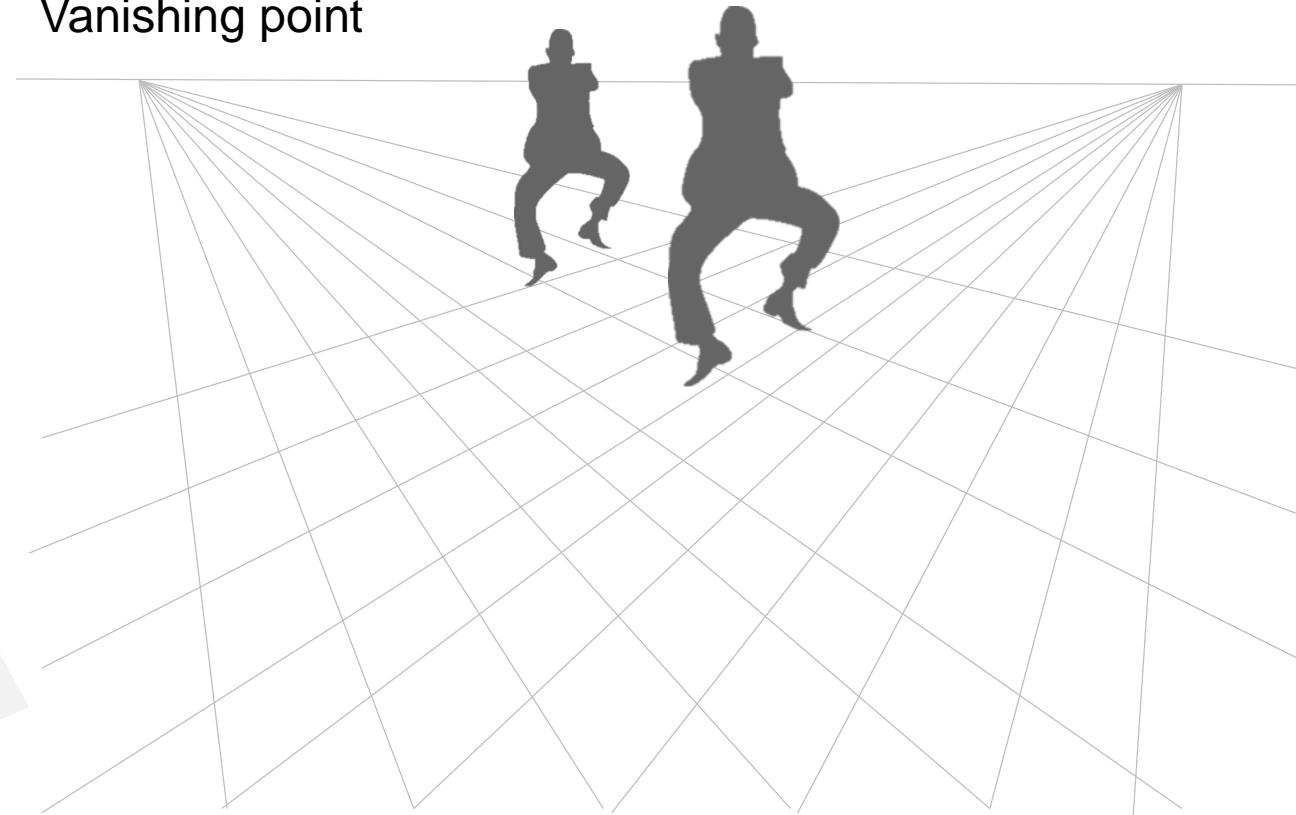
Height from Image



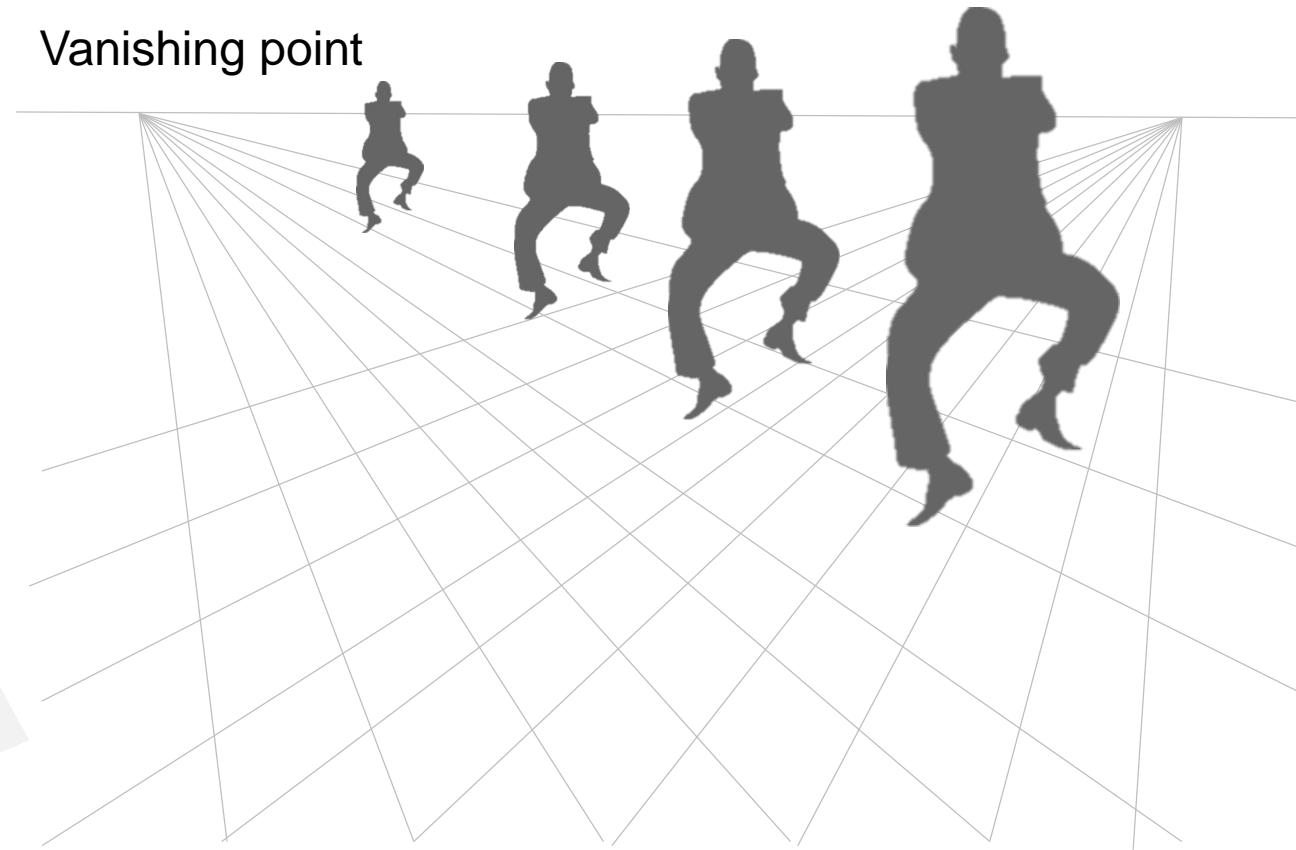
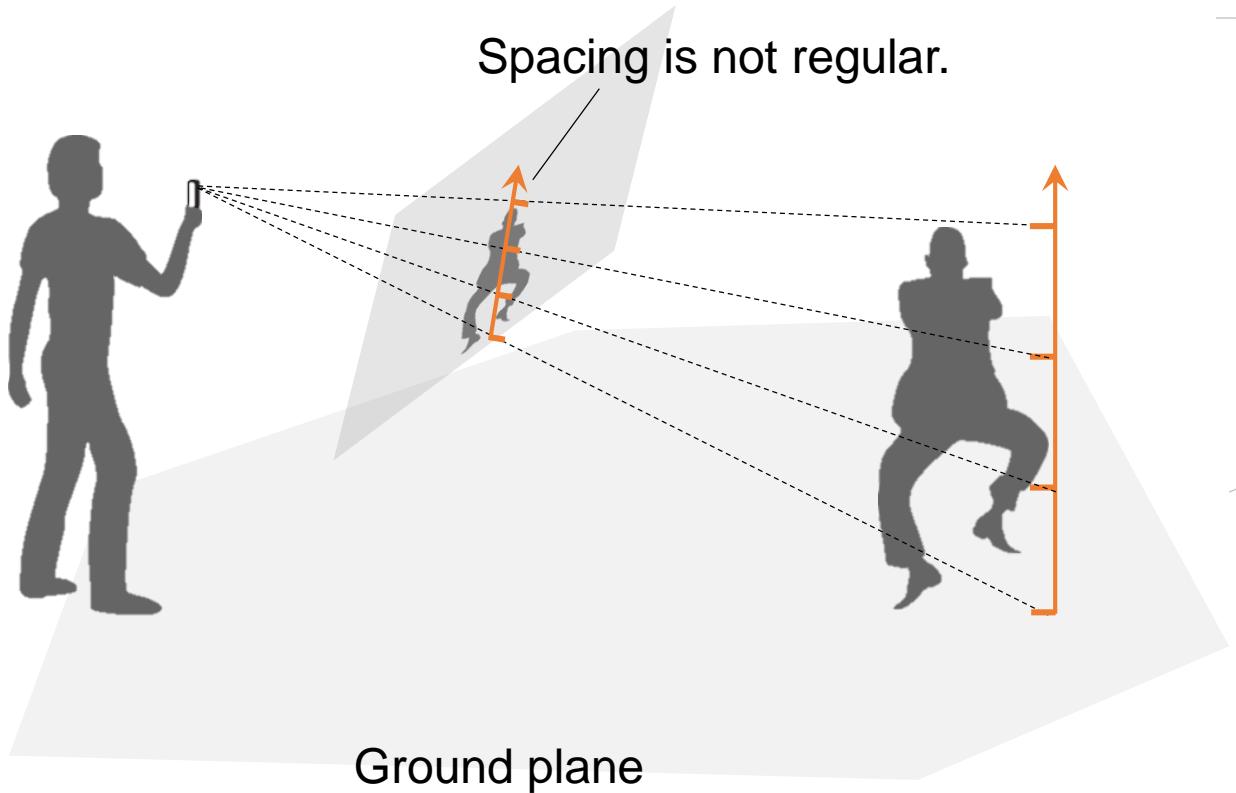
Height from Image



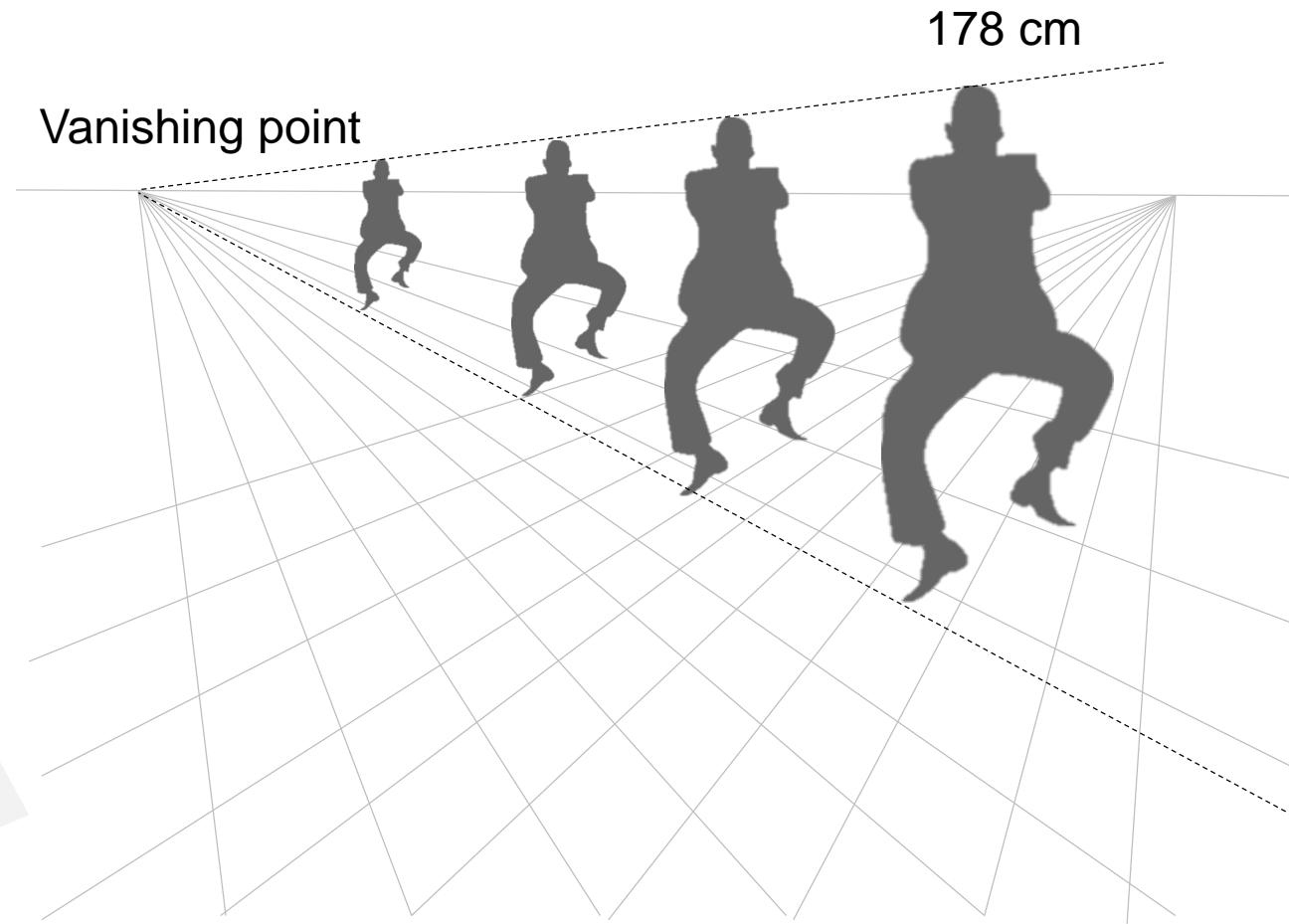
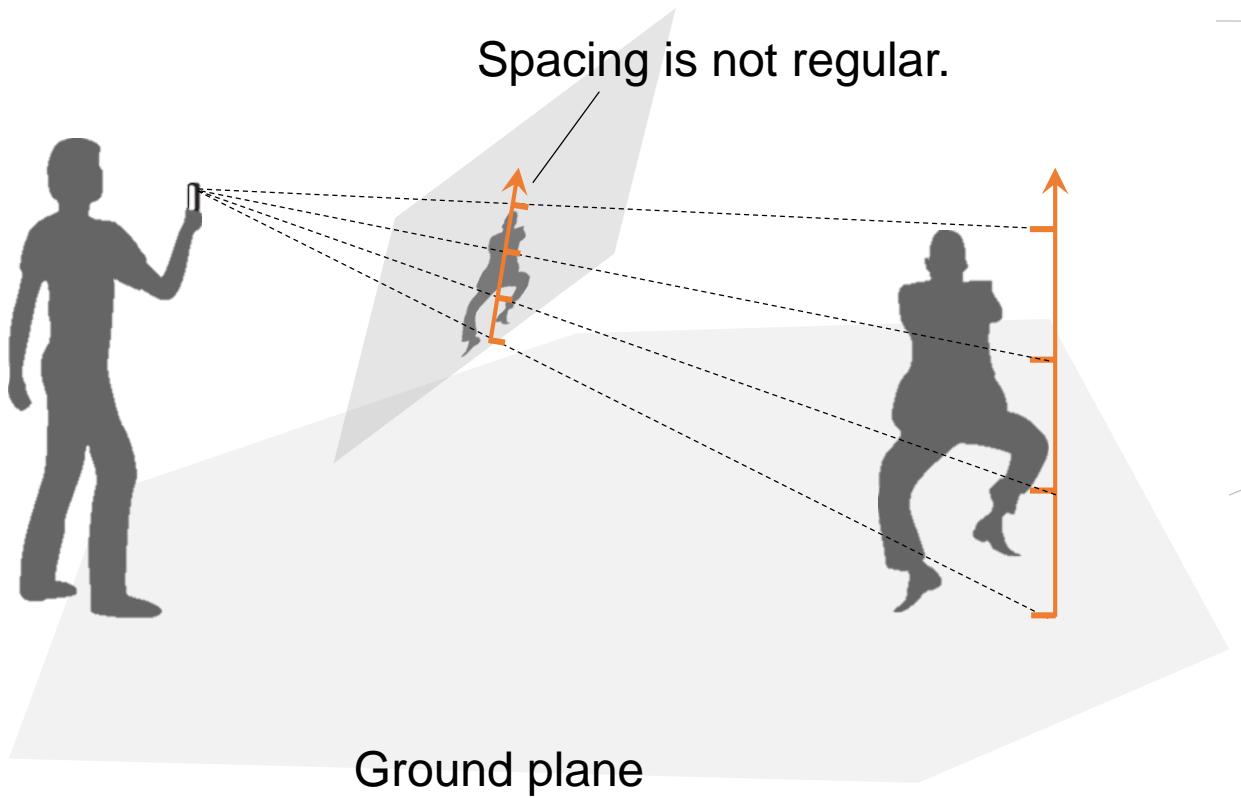
Vanishing point



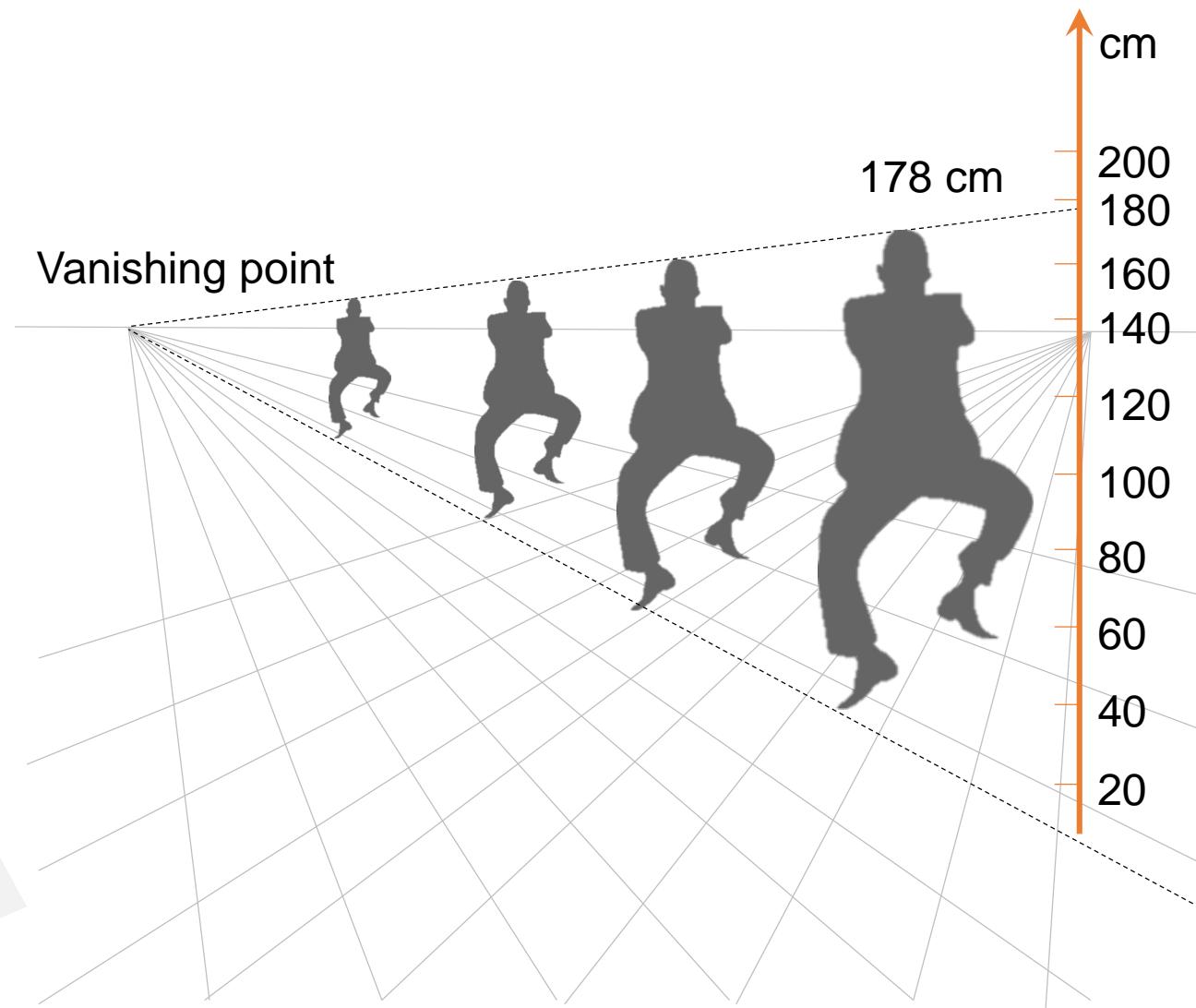
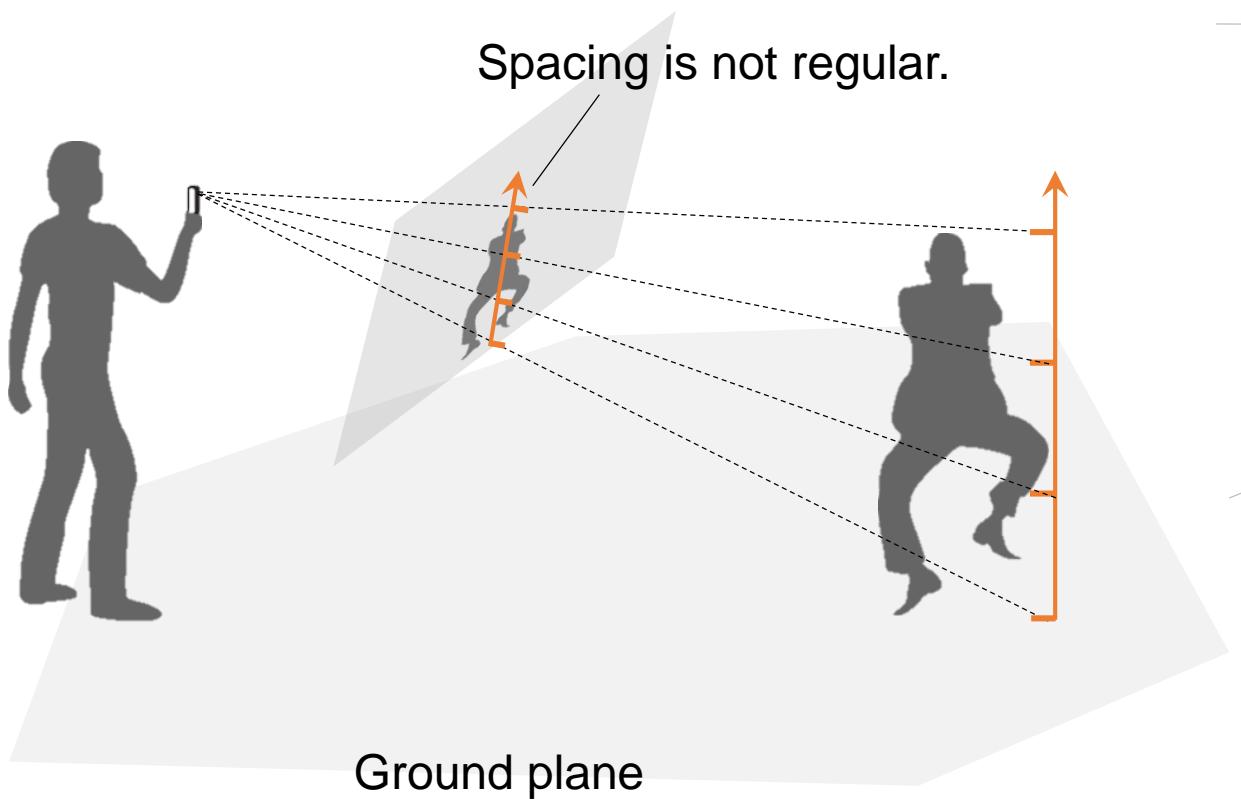
Height from Image



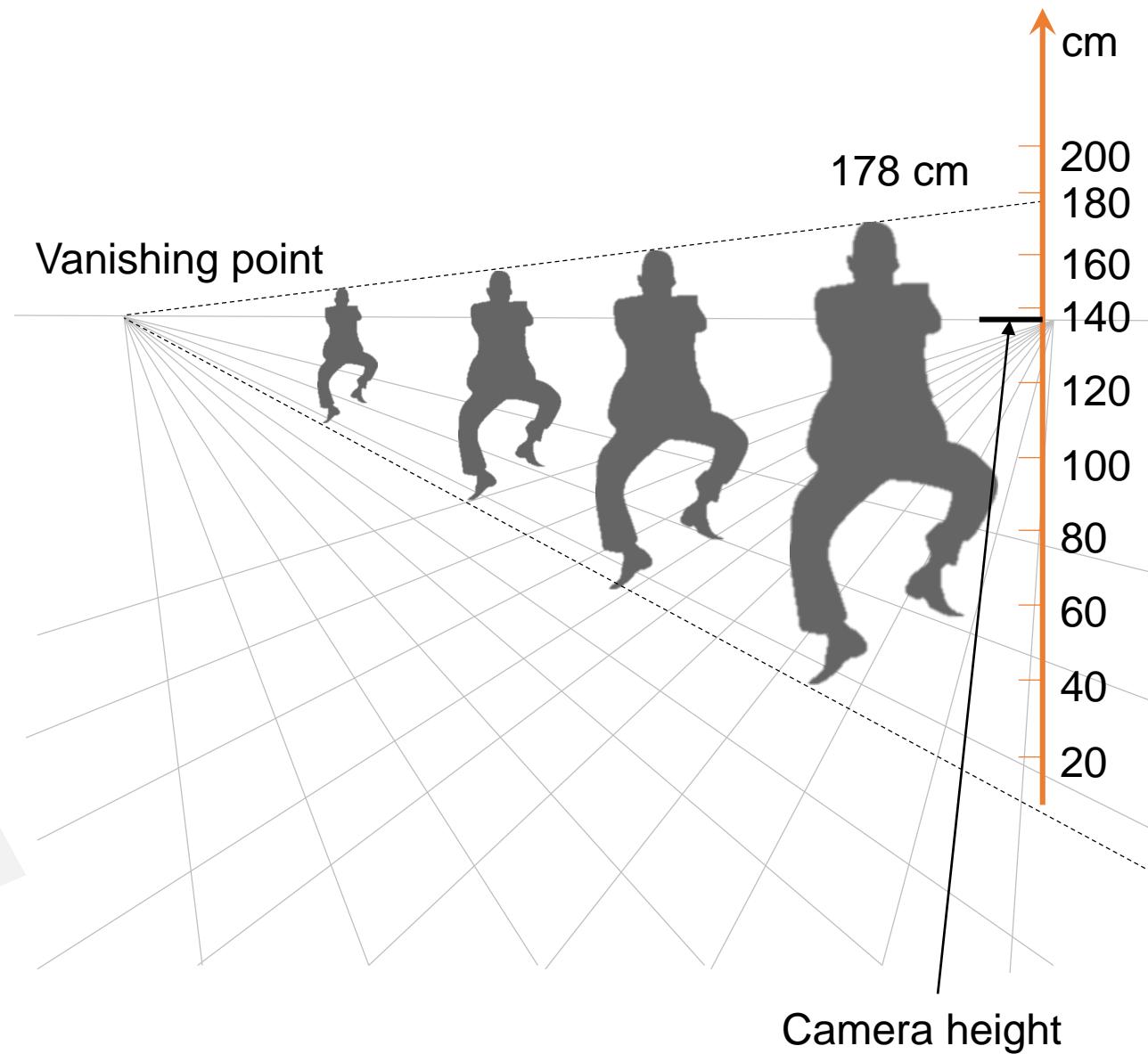
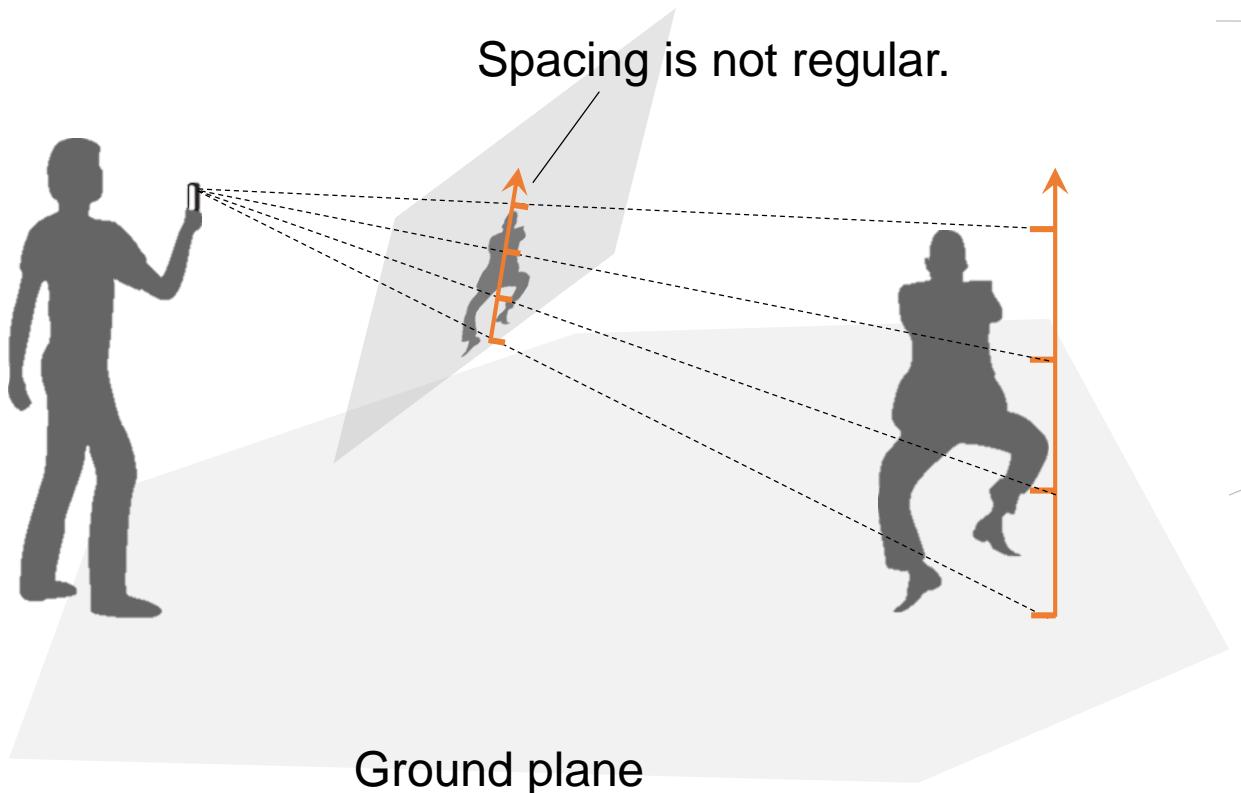
Height from Image



Height from Image



Height from Image



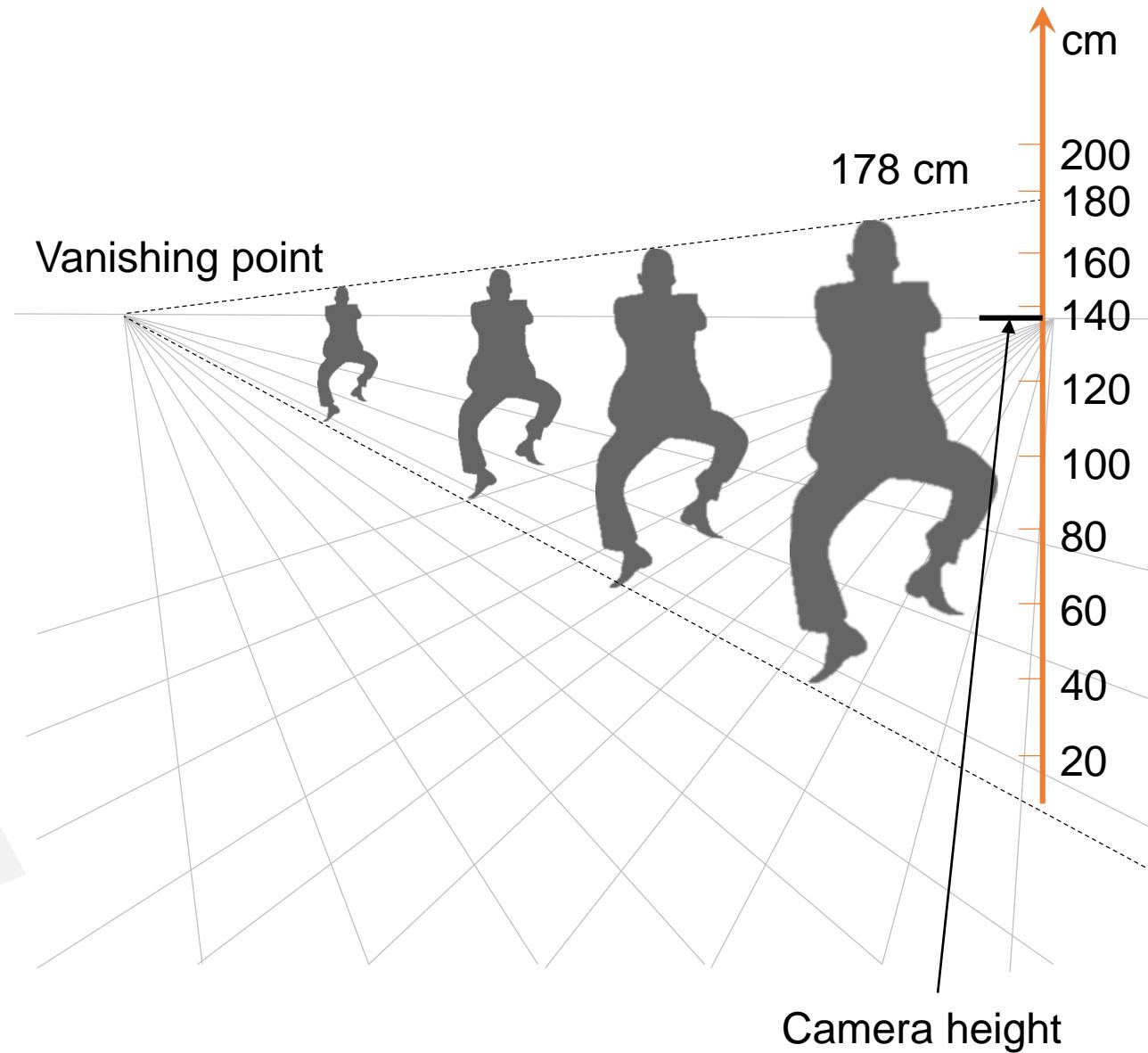
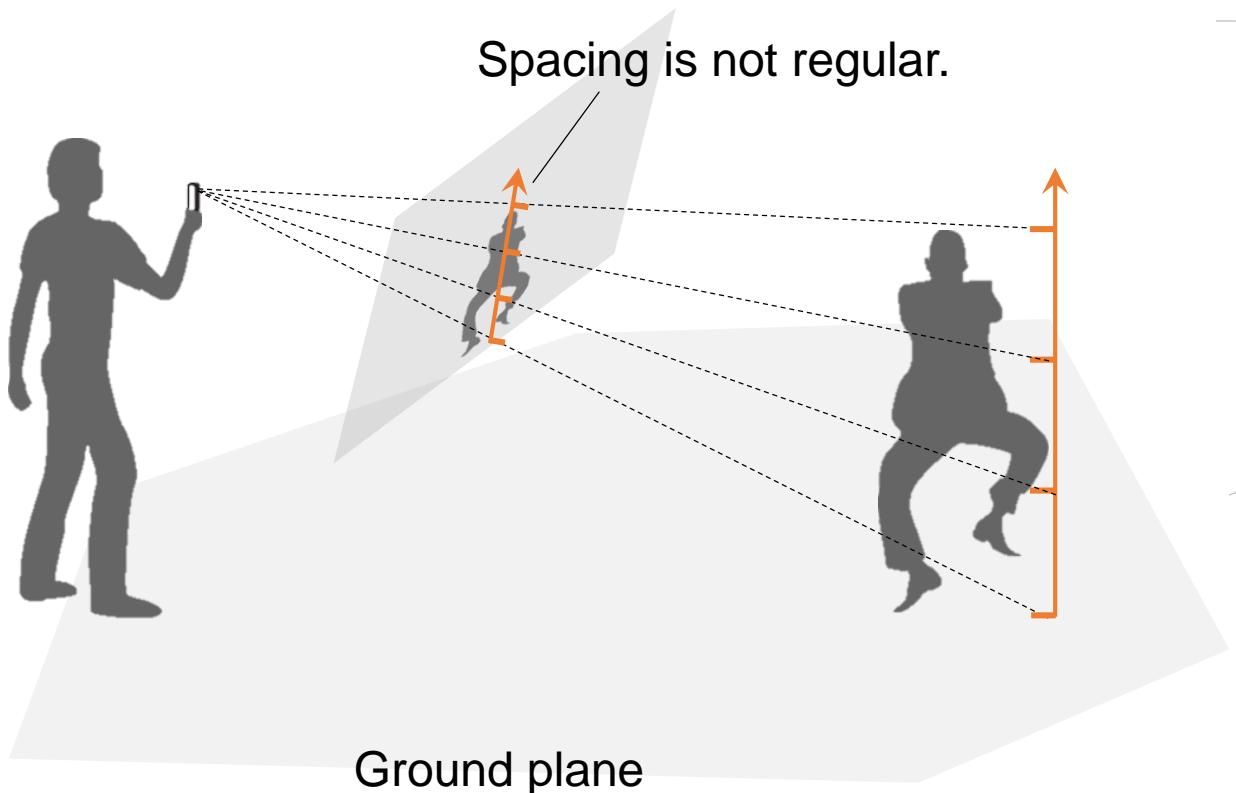
Where was I (how high)?



Taken from my hotel room (6th floor)

Taken from beach

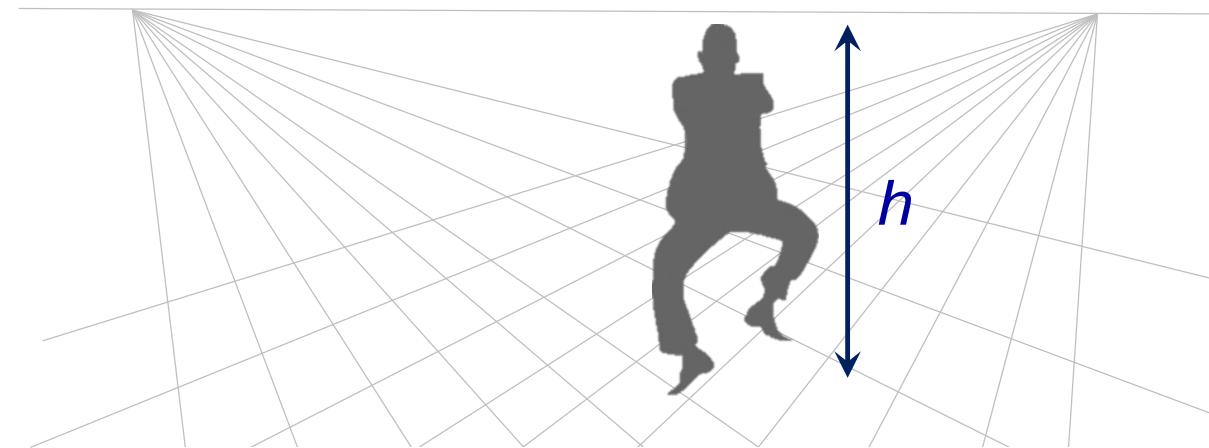
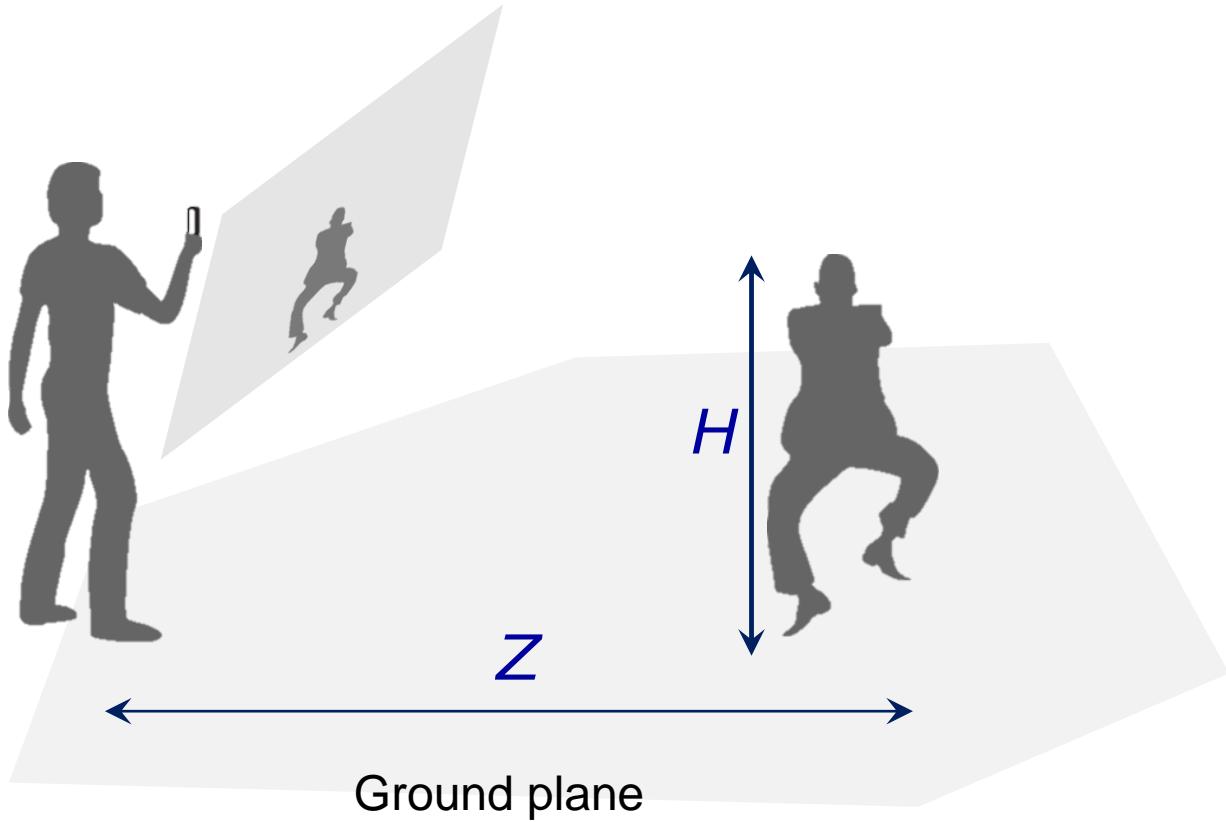
Height from Image



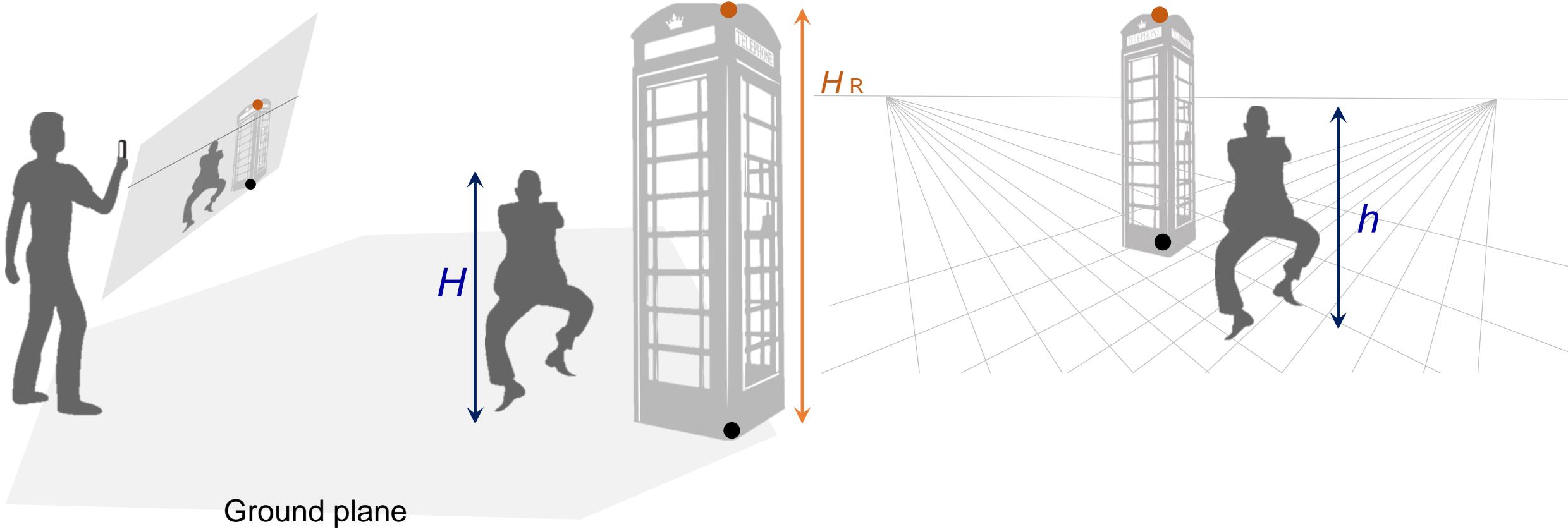
Height from Image

It is impossible to compute the height.

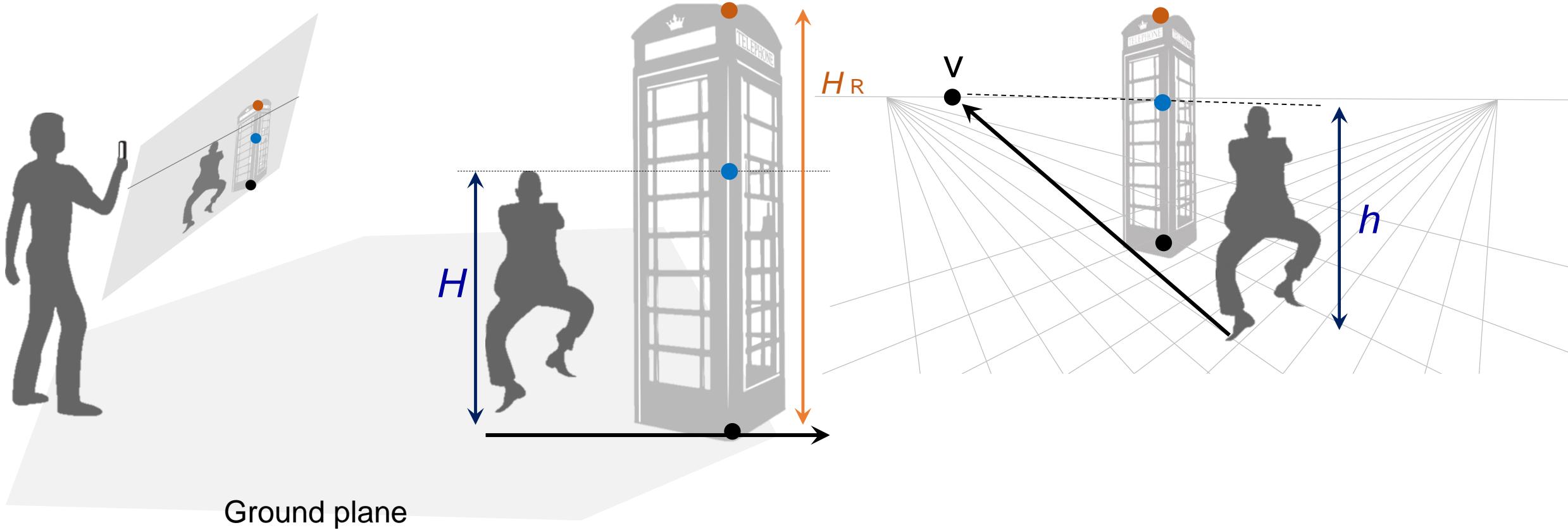
$$h = f \frac{H}{Z}$$

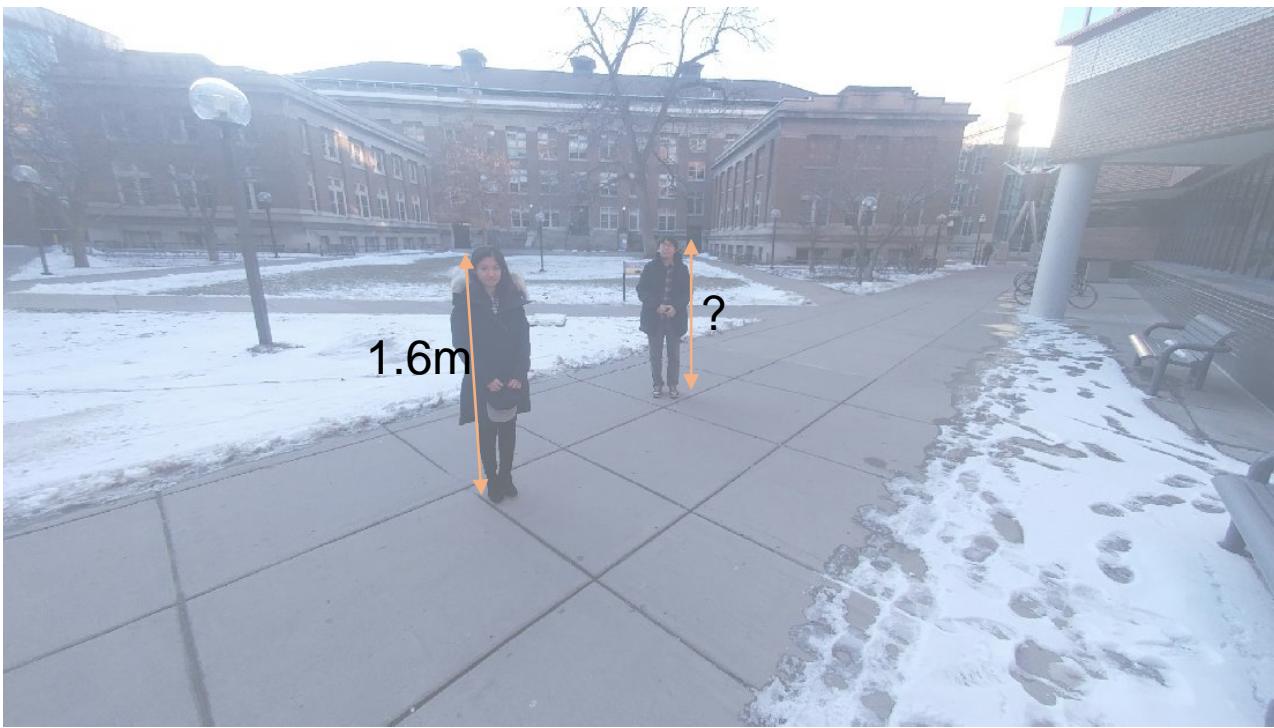


Height from Image

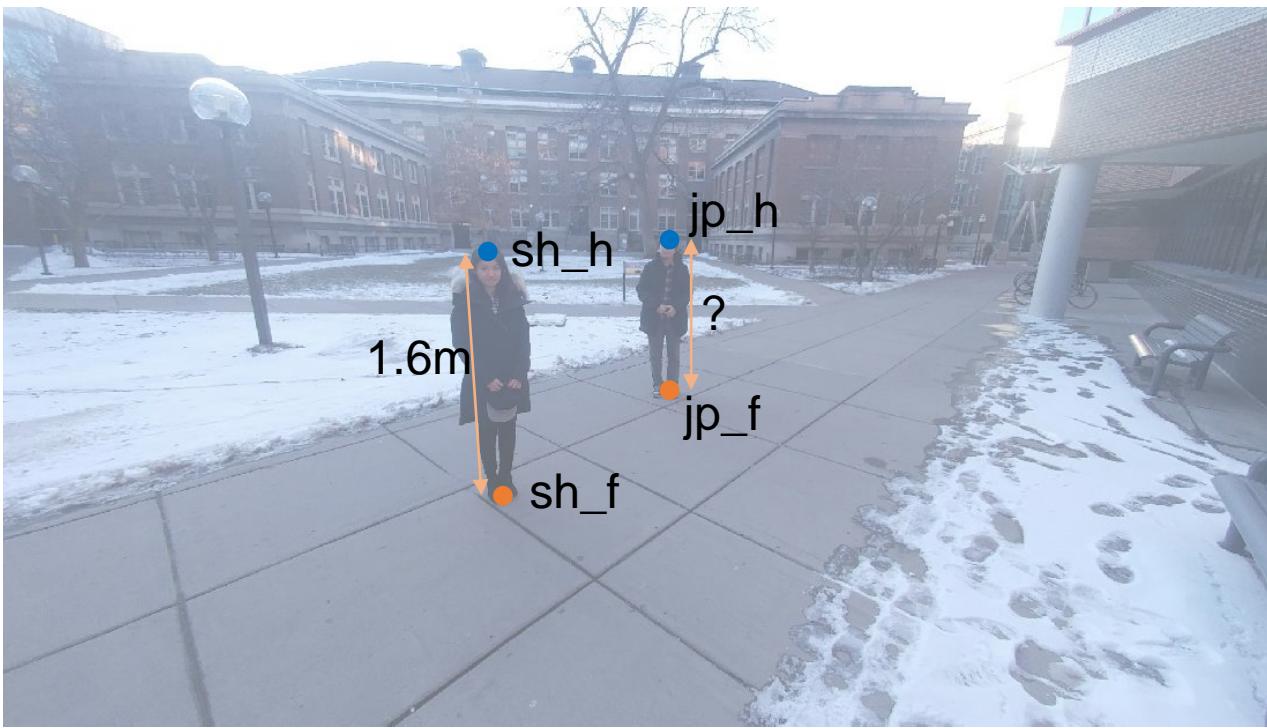


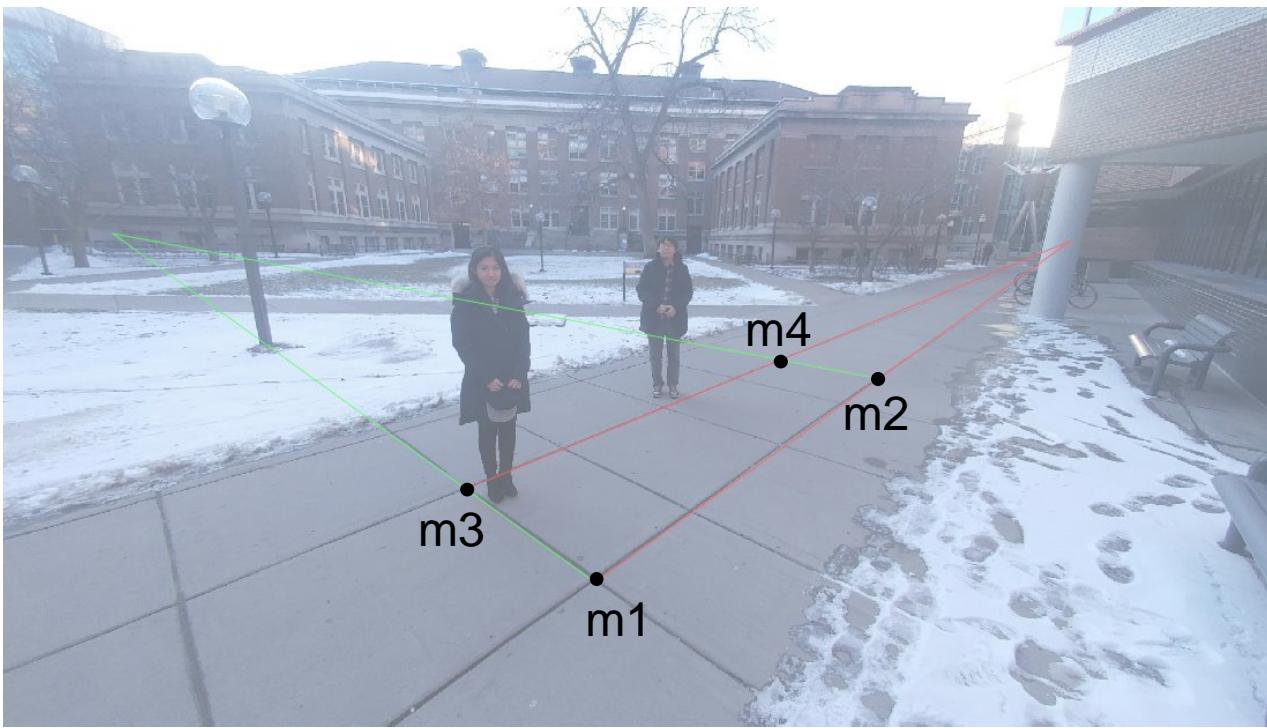
Height from Image





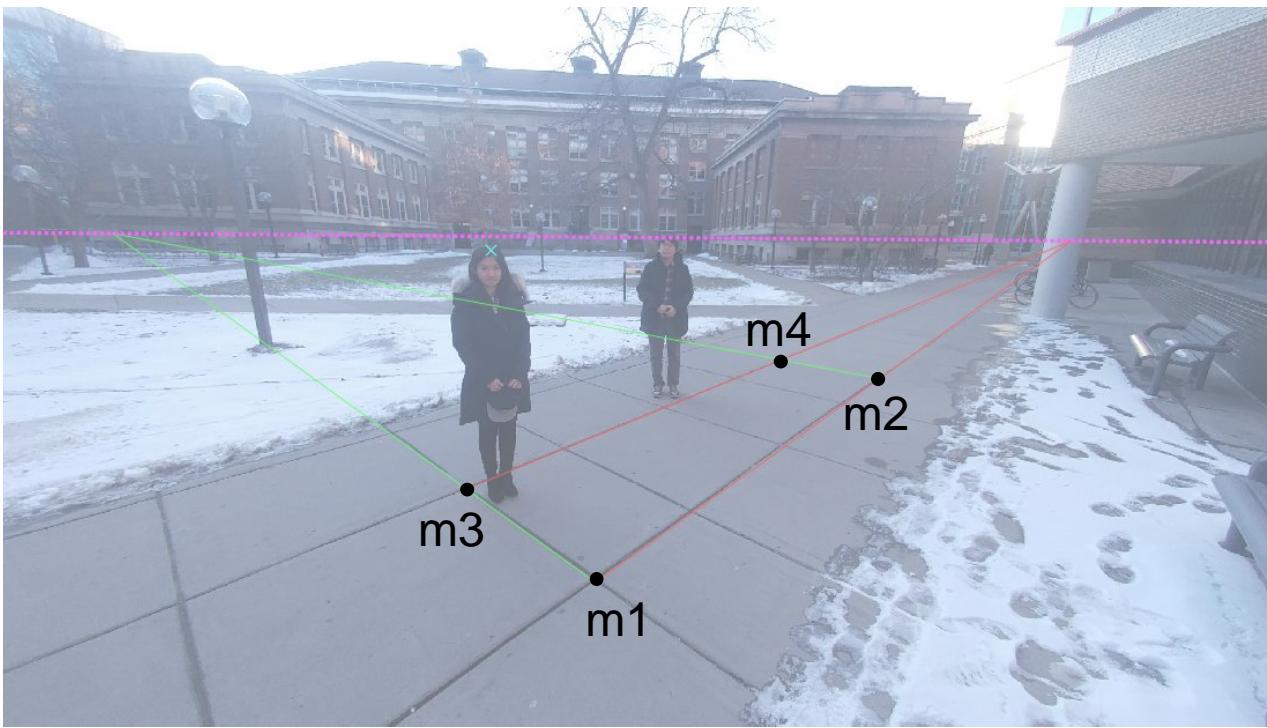
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sh_f = [1504;1447;1];  
sh_h = [1468;730;1];  
jp_f = [1997;1175;1];  
jp_h = [1997;695;1];
```





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jp_h = [1997;695;1];
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```
l11 = GetLineFromTwoPoints(m1,m2);  
l12 = GetLineFromTwoPoints(m3,m4);  
l21 = GetLineFromTwoPoints(m1,m3);  
l22 = GetLineFromTwoPoints(m2,m4);
```

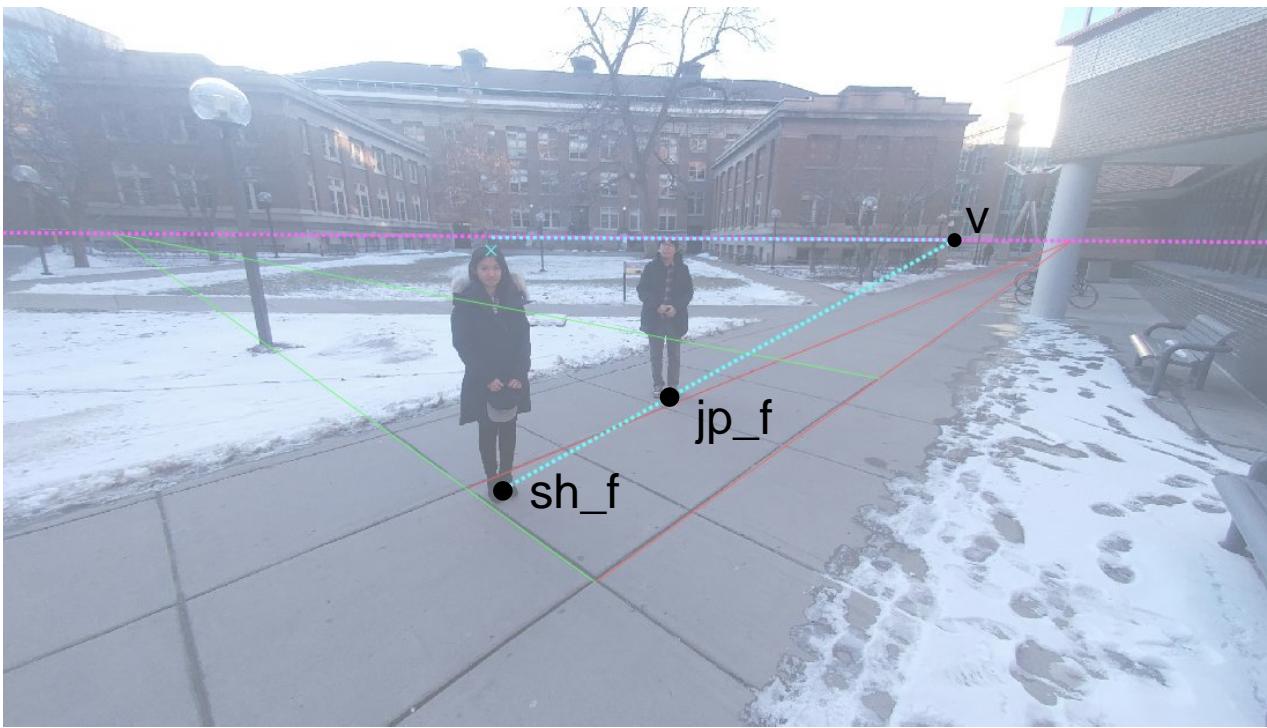


```
sh_f = [1504;1447;1];  
sh_h = [1468;730;1];  
jp_f = [1997;1175;1];  
jp_h = [1997;695;1];
```

```
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l12 = GetLineFromTwoPoints(m3,m4);  
l21 = GetLineFromTwoPoints(m1,m3);  
l22 = GetLineFromTwoPoints(m2,m4);
```

```
v1 = GetPointFromTwoLines(l11,l12);  
v2 = GetPointFromTwoLines(l21,l22);  
l = GetLineFromTwoPoints(v1,v2);
```

← Vanishing line



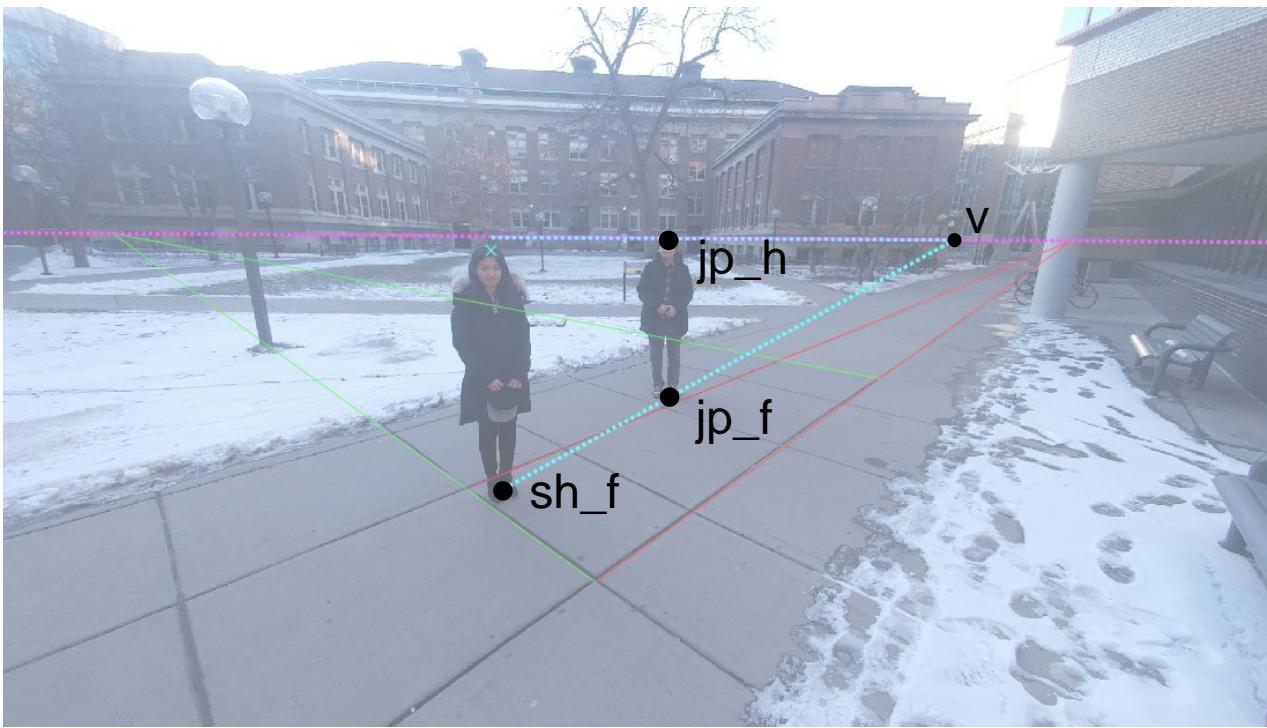
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l22 = GetLineFromTwoPoints(m2,m4);
```

```
v1 = GetPointFromTwoLines(l11,l12);  
v2 = GetPointFromTwoLines(l21,l22);  
l = GetLineFromTwoPoints(v1,v2);
```

← Vanishing line

```
line_sh_jp_f = GetLineFromTwoPoints(sh_f,jp_f);  
v = GetPointFromTwoLines(line_sh_jp_f,l);
```



```
sh_f = [1504;1447;1];  
sh_h = [1468;730;1];  
jp_f = [1997;1175;1];  
jp_h = [1997;695;1];
```

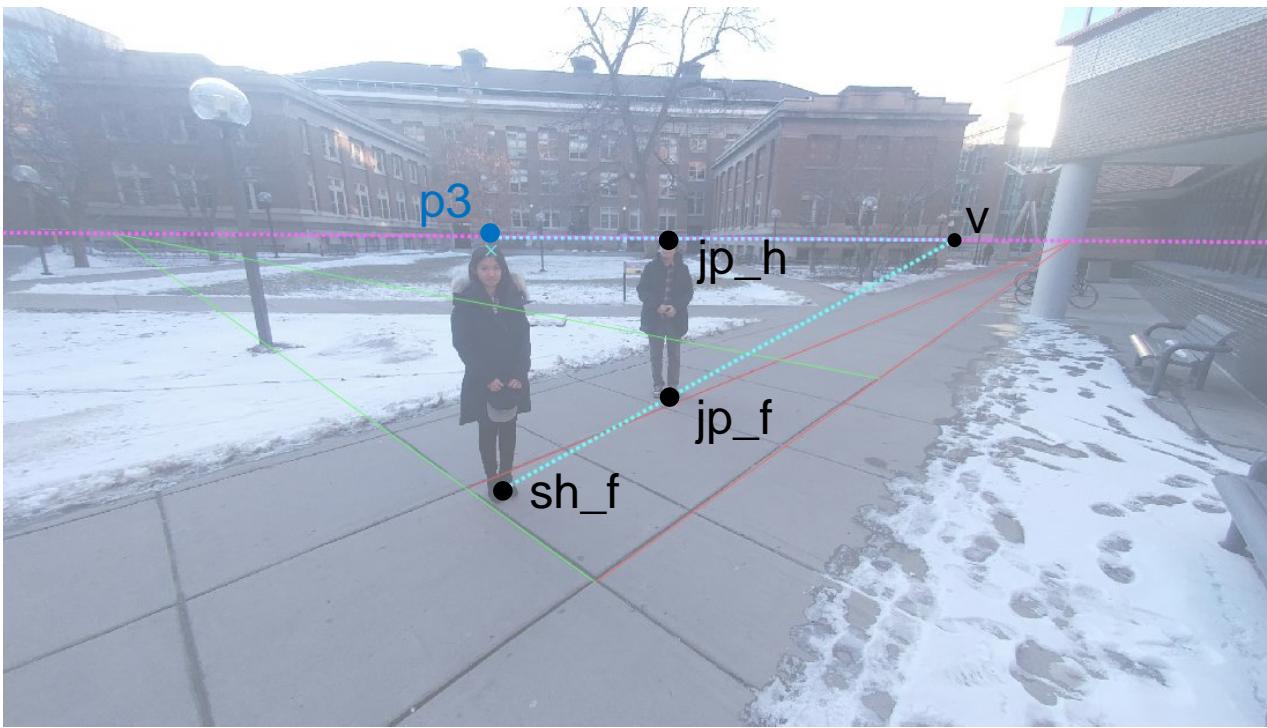
```
l11 = GetLineFromTwoPoints(m1,m2);  
l12 = GetLineFromTwoPoints(m3,m4);  
l21 = GetLineFromTwoPoints(m1,m3);  
l22 = GetLineFromTwoPoints(m2,m4);
```

```
v1 = GetPointFromTwoLines(l11,l12);  
v2 = GetPointFromTwoLines(l21,l22);  
l = GetLineFromTwoPoints(v1,v2);
```

← Vanishing line

```
line_sh_jp_f = GetLineFromTwoPoints(sh_f, jp_f);  
v = GetPointFromTwoLines(line_sh_jp_f, l);
```

```
line_jp_h_v = GetLineFromTwoPoints(jp_head, v);
```



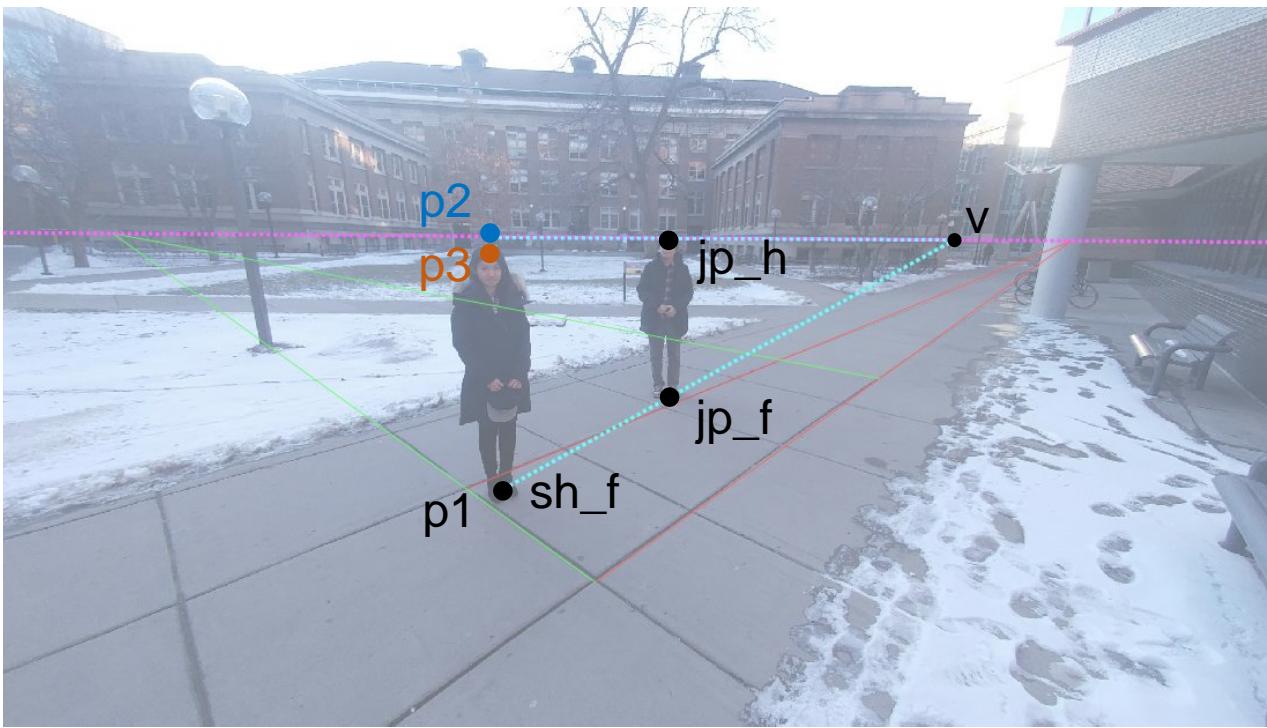
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jp_f = [1997;1175;1];  
jp_h = [1997;695;1];
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l22 = GetLineFromTwoPoints(m2,m4);
```

```
v1 = GetPointFromTwoLines(l11,l12);  
v2 = GetPointFromTwoLines(l21,l22);  
l = GetLineFromTwoPoints(v1,v2);
```

← Vanishing line

```
line_sh_jp_f = GetLineFromTwoPoints(sh_f, jp_f);  
v = GetPointFromTwoLines(line_sh_jp_f, l);  
  
line_jp_h_v = GetLineFromTwoPoints(jp_head, v);  
line_sh = GetLineFromTwoPoints(sh_h, sh_f);  
p2 = GetPointFromTwoLines(line_jp_head_v, line_sh);
```



```
sh_f = [1504;1447;1];  
sh_h = [1468;730;1];  
jp_f = [1997;1175;1];  
jp_h = [1997;695;1];
```

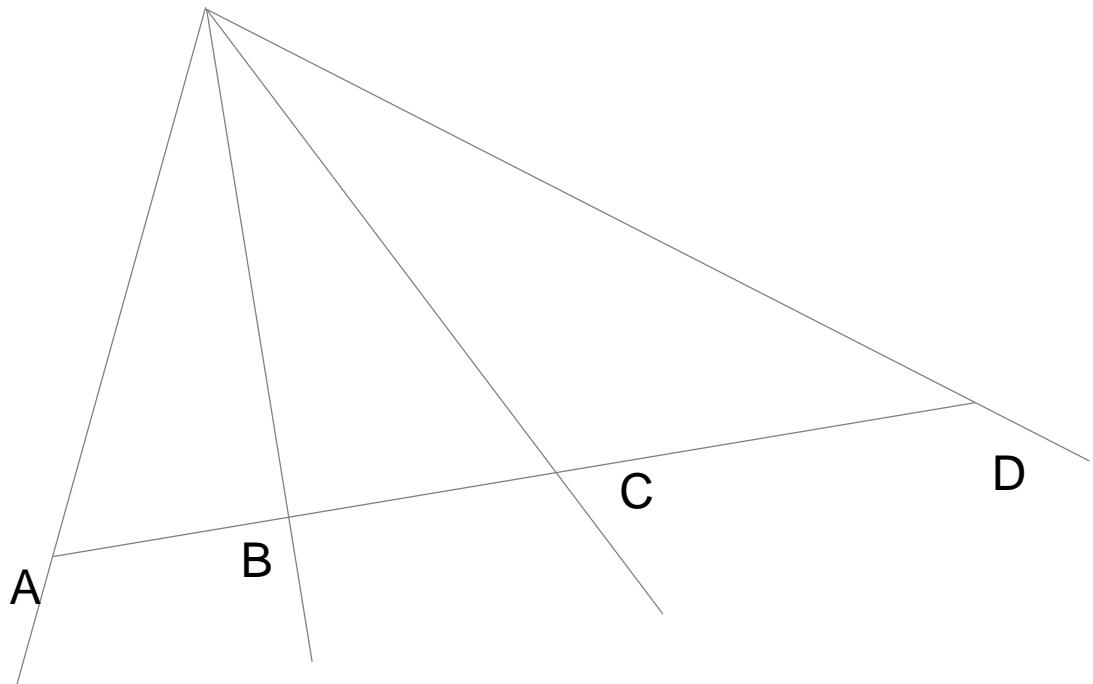
```
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l21 = GetLineFromTwoPoints(m1,m3);  
l22 = GetLineFromTwoPoints(m2,m4);
```

```
v1 = GetPointFromTwoLines(l11,l12);  
v2 = GetPointFromTwoLines(l21,l22);  
l = GetLineFromTwoPoints(v1,v2);
```

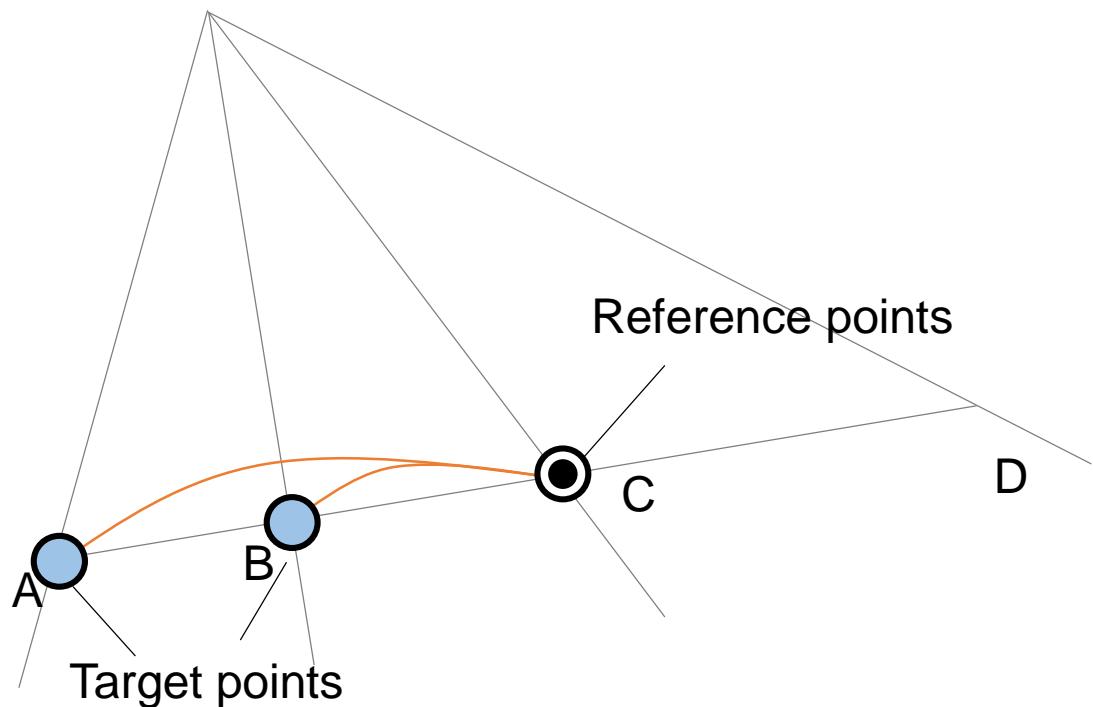
← Vanishing line

```
line_sh_jp_f = GetLineFromTwoPoints(sh_f, jp_f);  
v = GetPointFromTwoLines(line_sh_jp_f, l);  
  
line_jp_h_v = GetLineFromTwoPoints(jp_head, v);  
line_sh = GetLineFromTwoPoints(sh_h, sh_f);  
p2 = GetPointFromTwoLines(line_jp_head_v, line_sh);  
p3 = sh_h;  
p1 = sh_f;
```

Cross Ratio

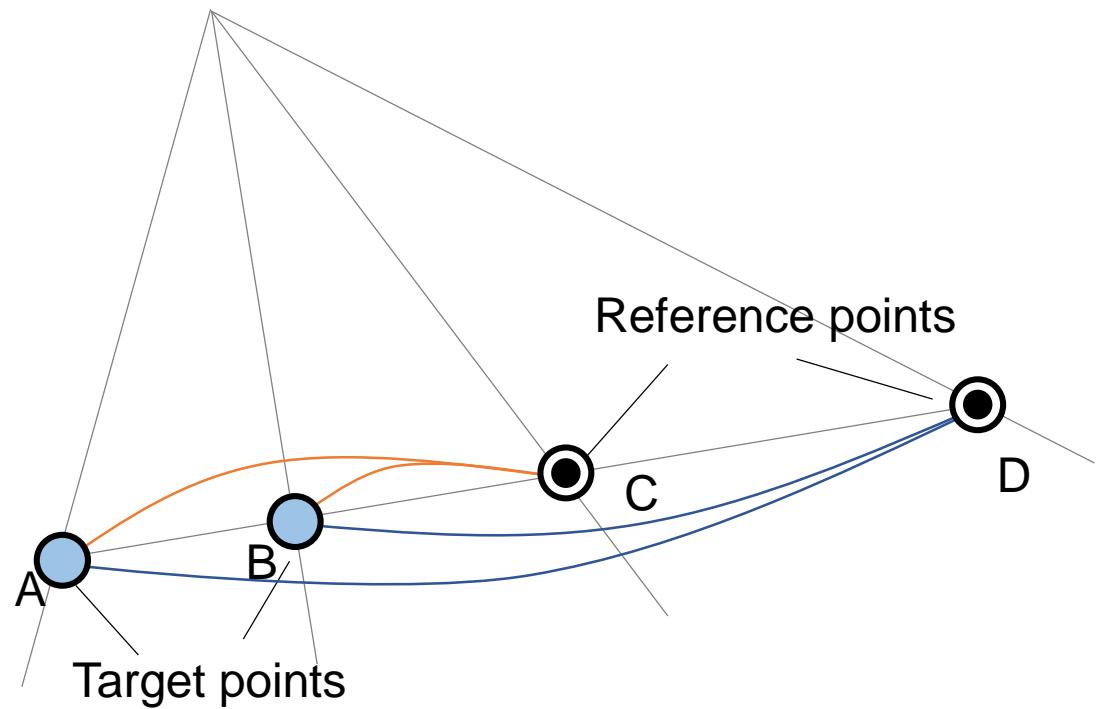


Cross Ratio



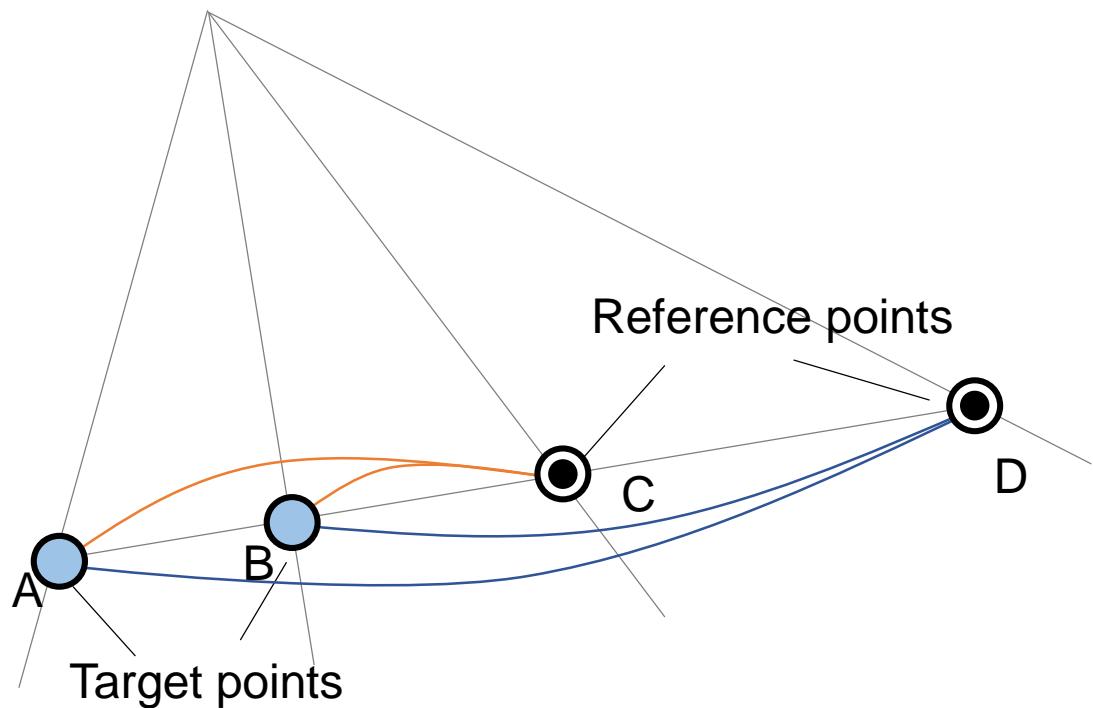
$$\frac{AC}{BC}$$

Cross Ratio



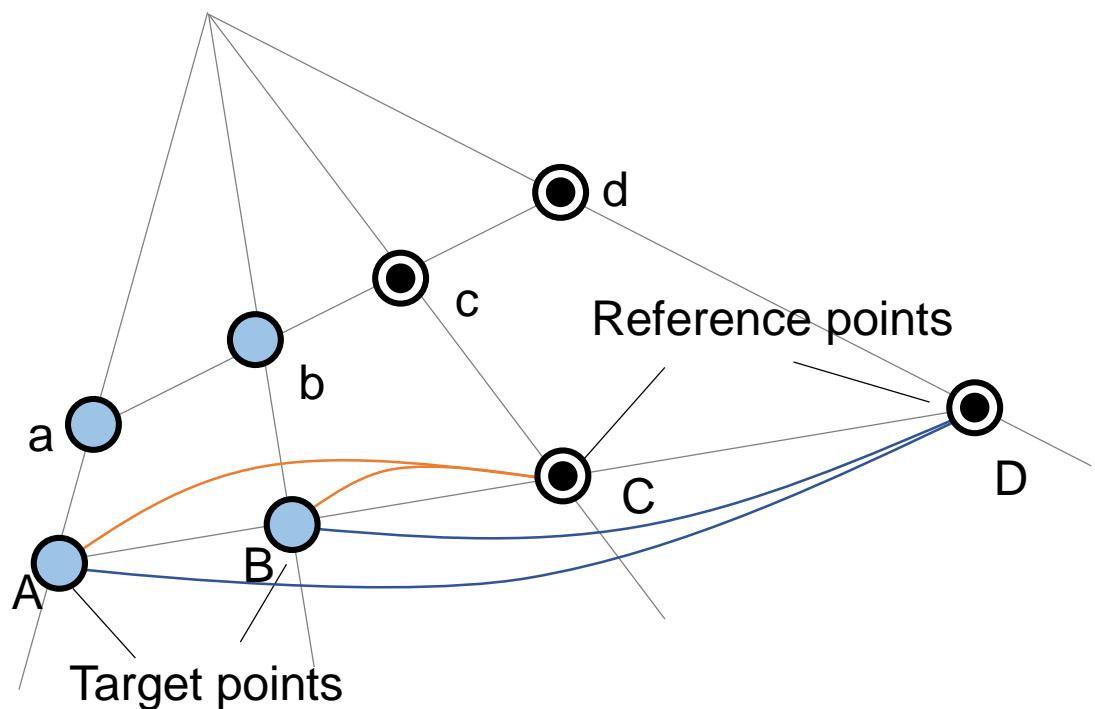
$$\frac{\overline{AC} \overline{BD}}{\overline{BC} \overline{AD}}$$

Cross Ratio



$$\frac{\overline{AC} \overline{BD}}{\overline{BC} \overline{AD}}$$

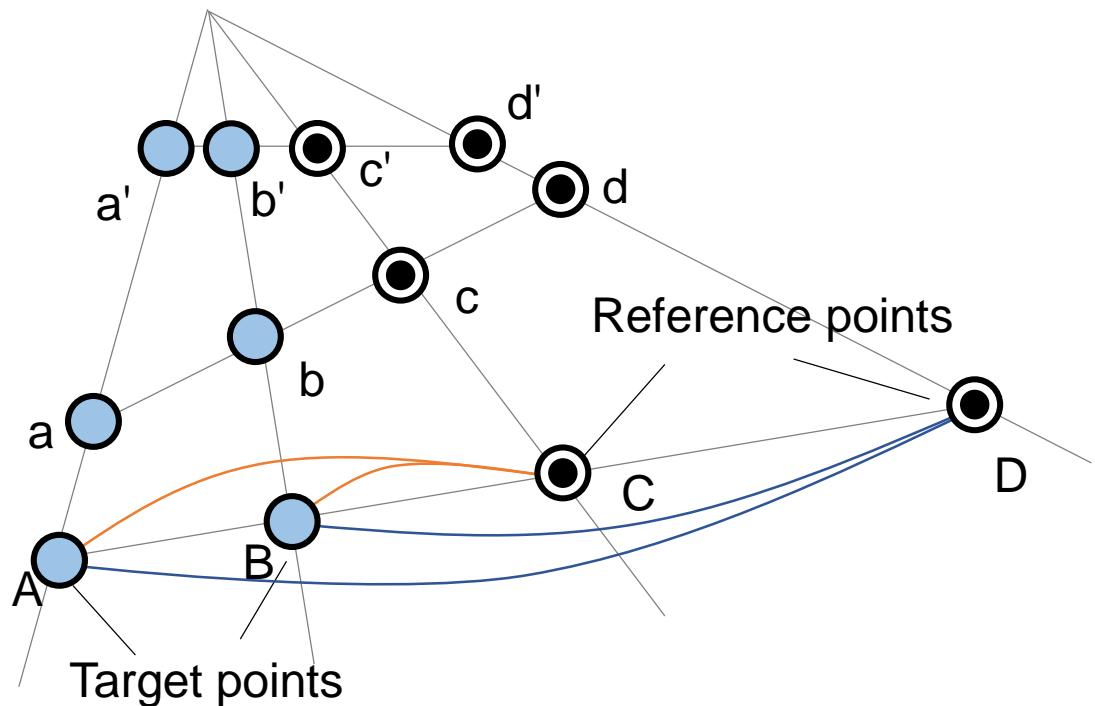
Cross Ratio



$$\frac{\overline{AC} \overline{BD}}{\overline{BC} \overline{AD}} = \frac{\overline{ac} \overline{bd}}{\overline{bc} \overline{ad}}$$

Cross ratio (perspective transformation invariant)

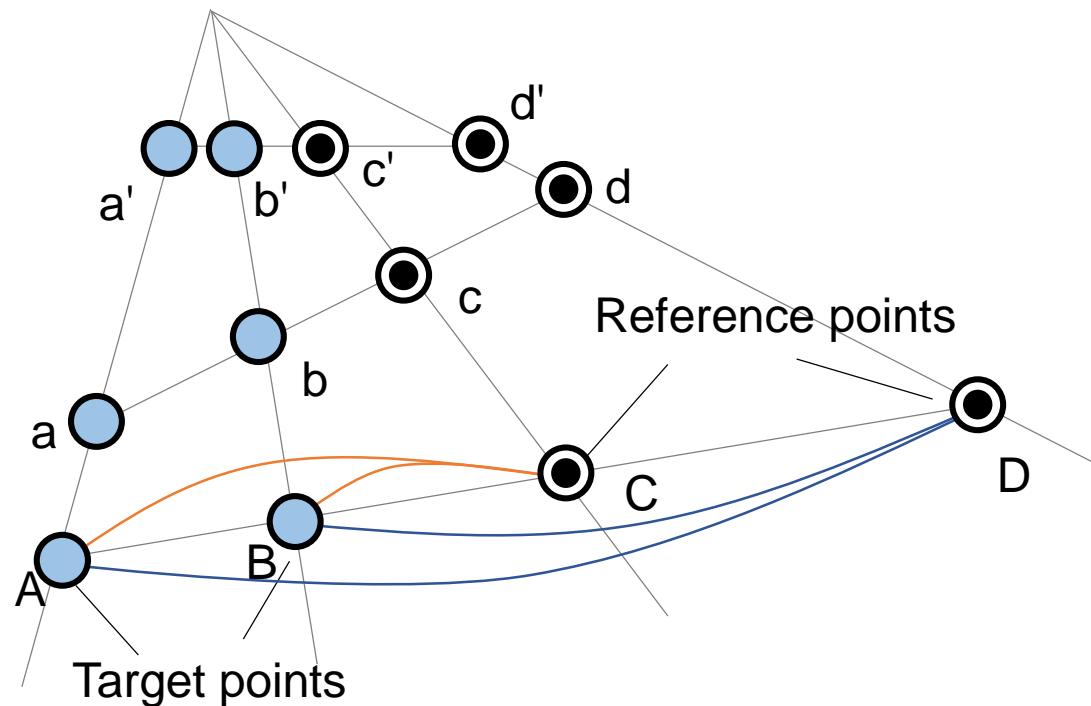
Cross Ratio



$$\frac{\overline{AC} \overline{BD}}{\overline{BC} \overline{AD}} = \frac{\overline{ac} \overline{bd}}{\overline{bc} \overline{ad}} = \frac{\overline{a'c'} \overline{b'd'}}{\overline{b'c'} \overline{a'd'}}$$

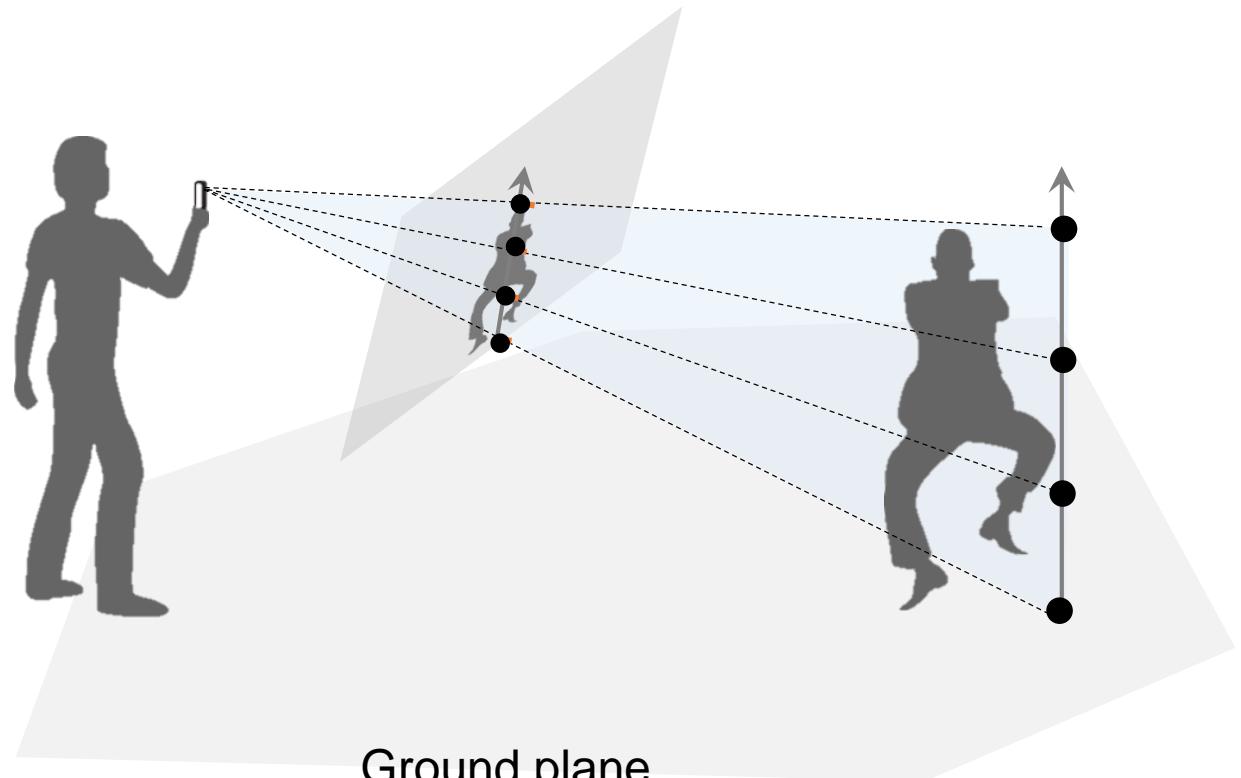
Cross ratio (perspective transformation invariant)

Cross Ratio

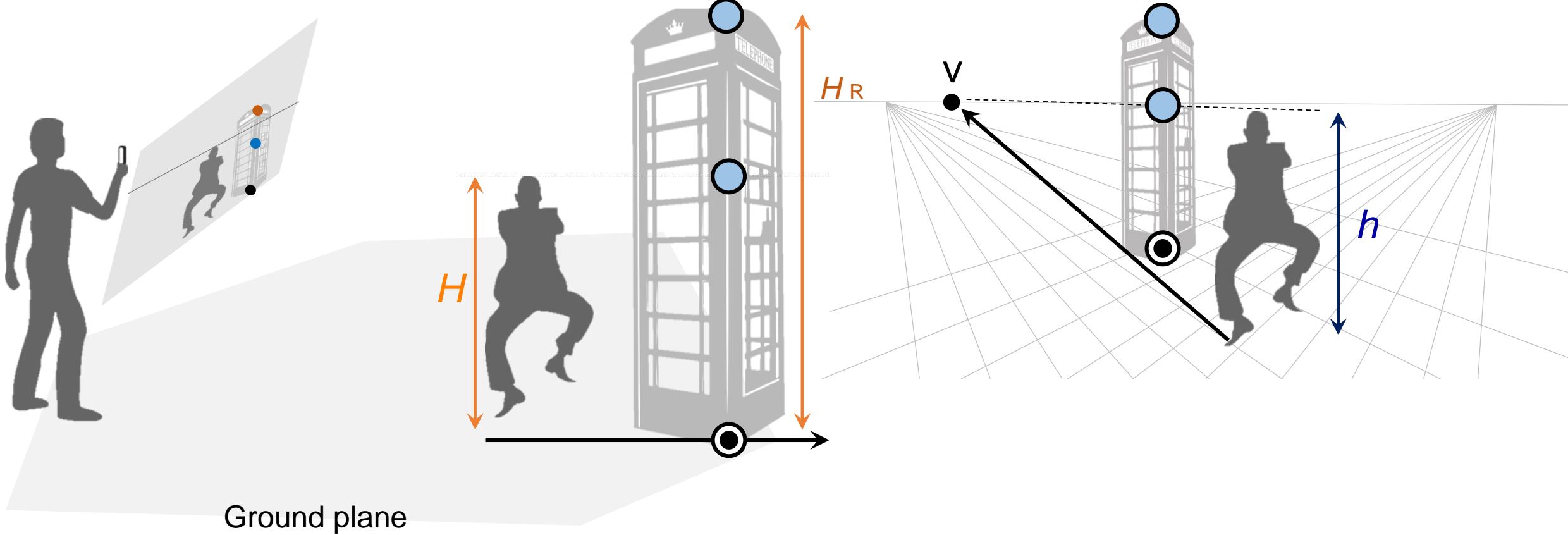


$$\frac{\overline{AC} \overline{BD}}{\overline{BC} \overline{AD}} = \frac{\overline{ac} \overline{bd}}{\overline{bc} \overline{ad}} = \frac{\overline{a'c'} \overline{b'd'}}{\overline{b'c'} \overline{a'd'}}$$

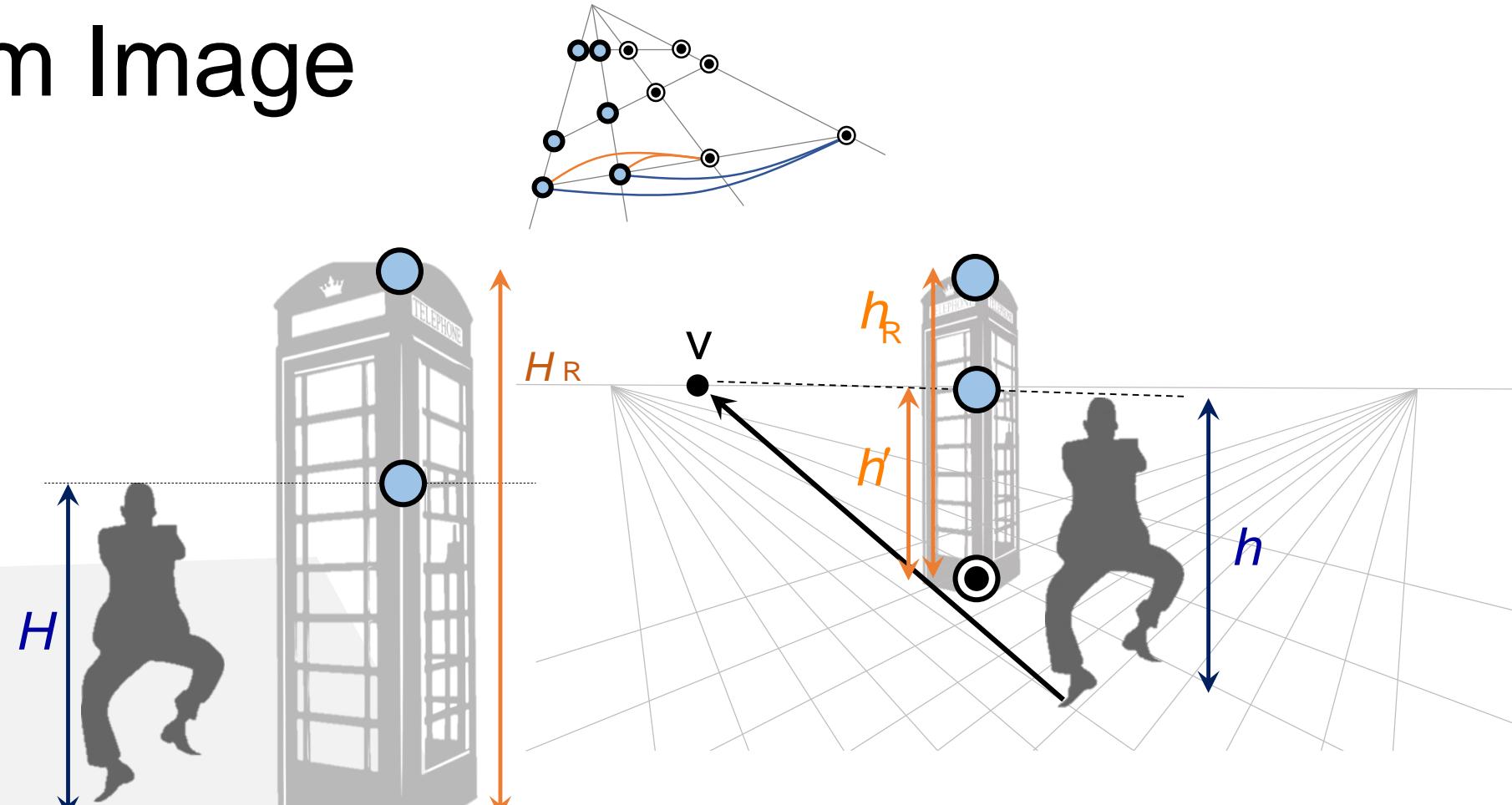
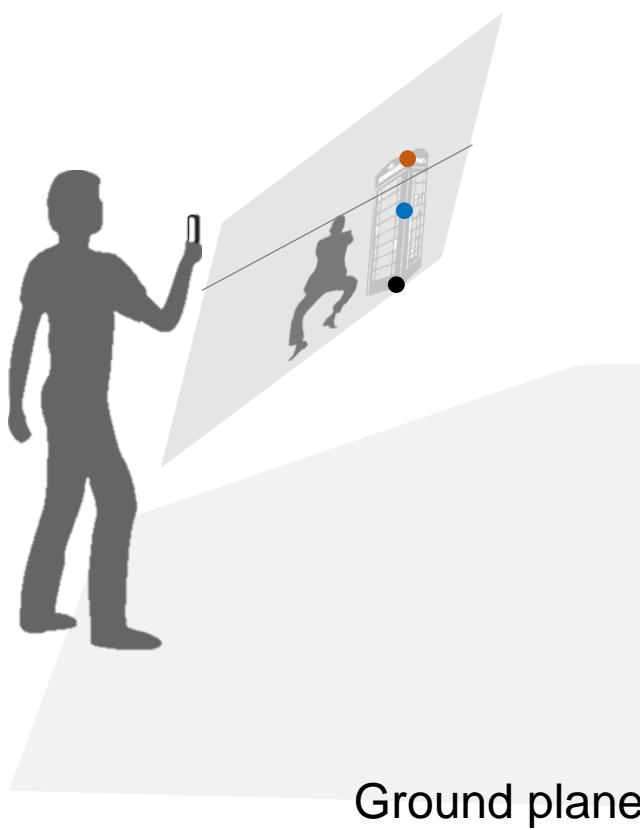
Cross ratio (perspective transformation invariant)



Height from Image

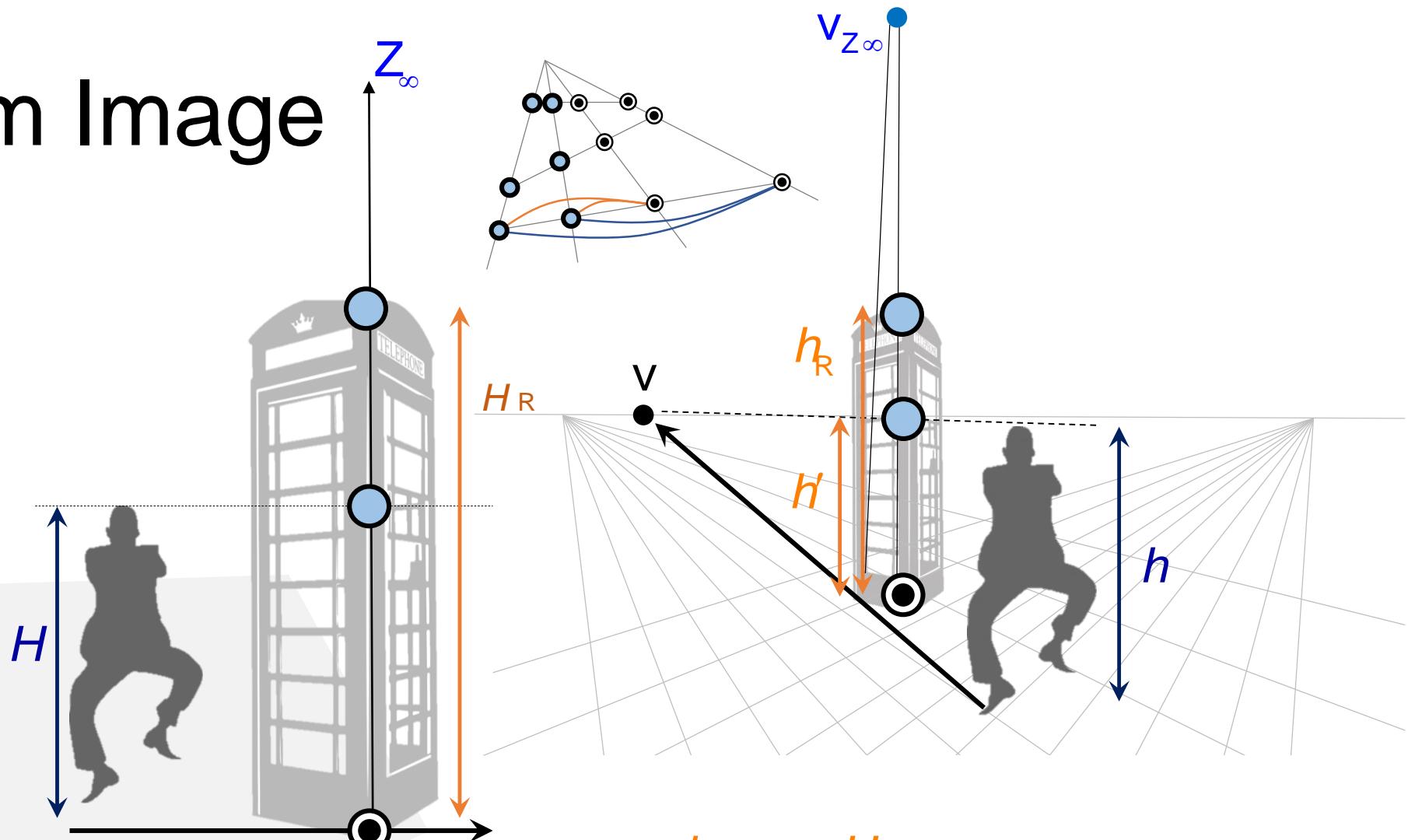
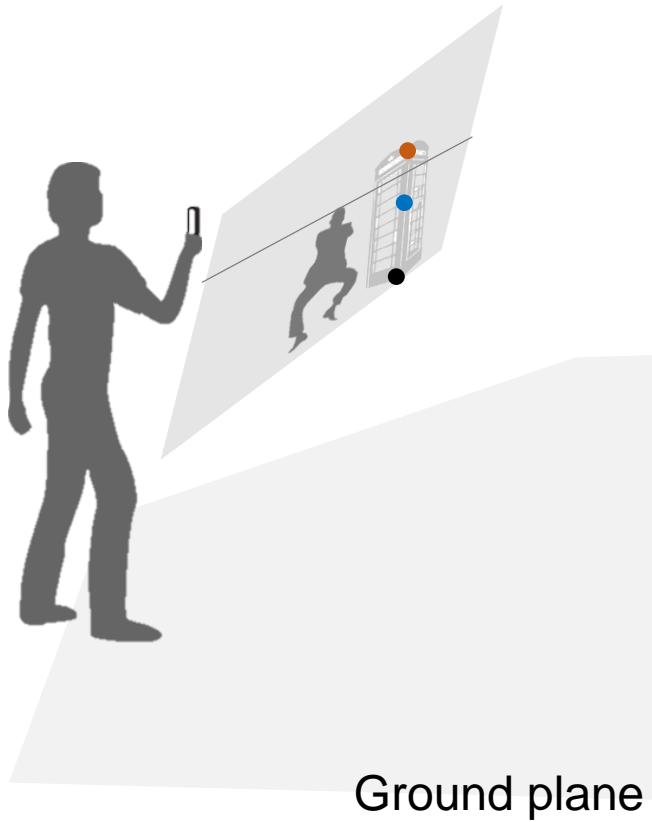


Height from Image



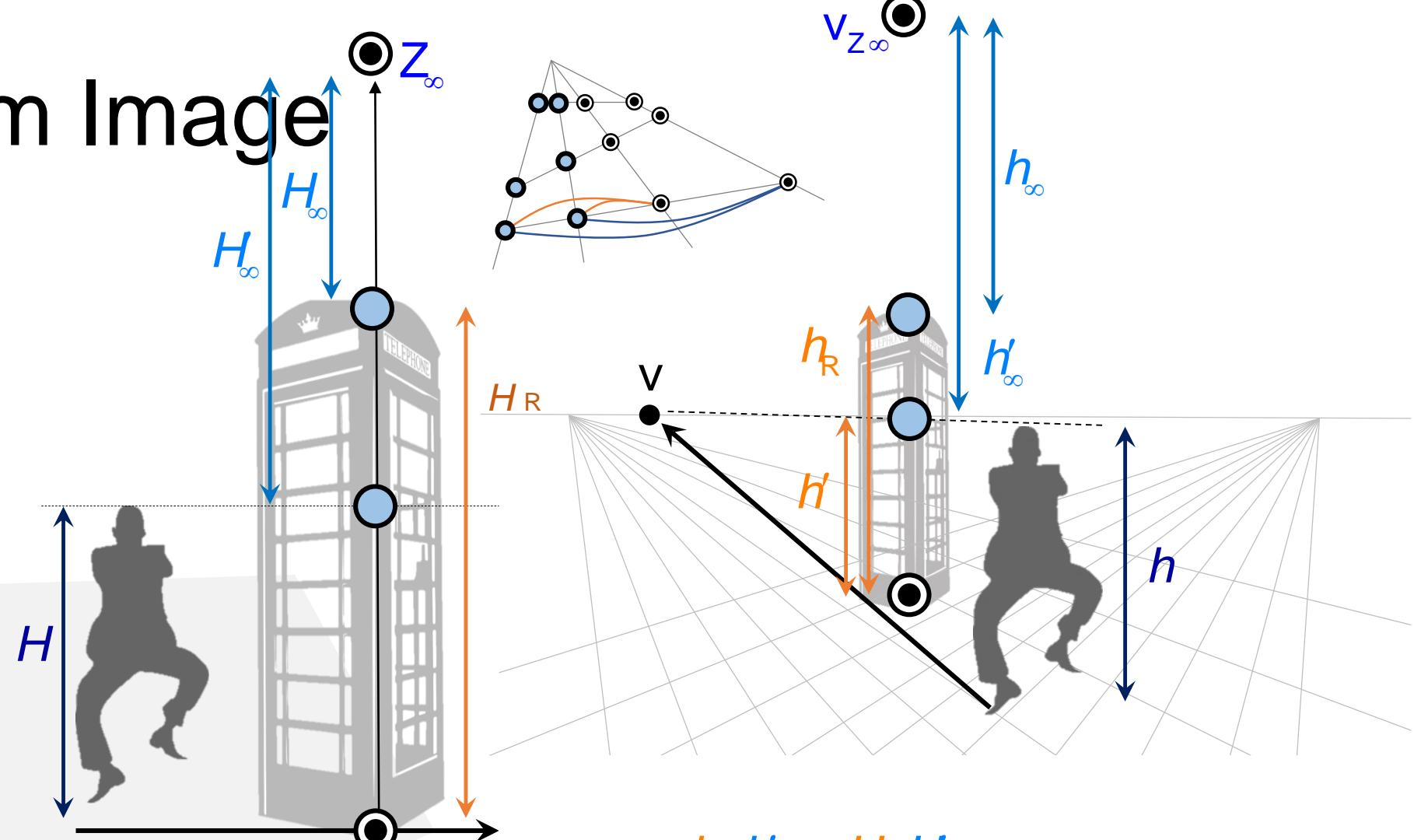
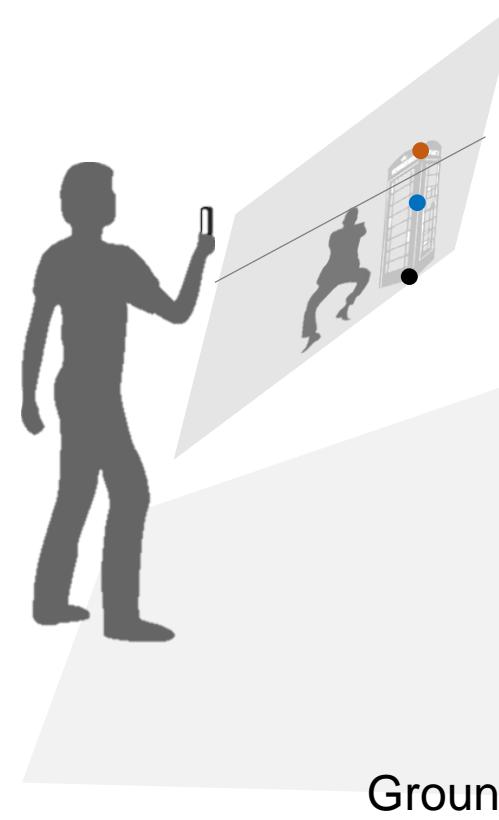
$$\frac{h_R}{h} = \frac{H_R}{H}$$

Height from Image



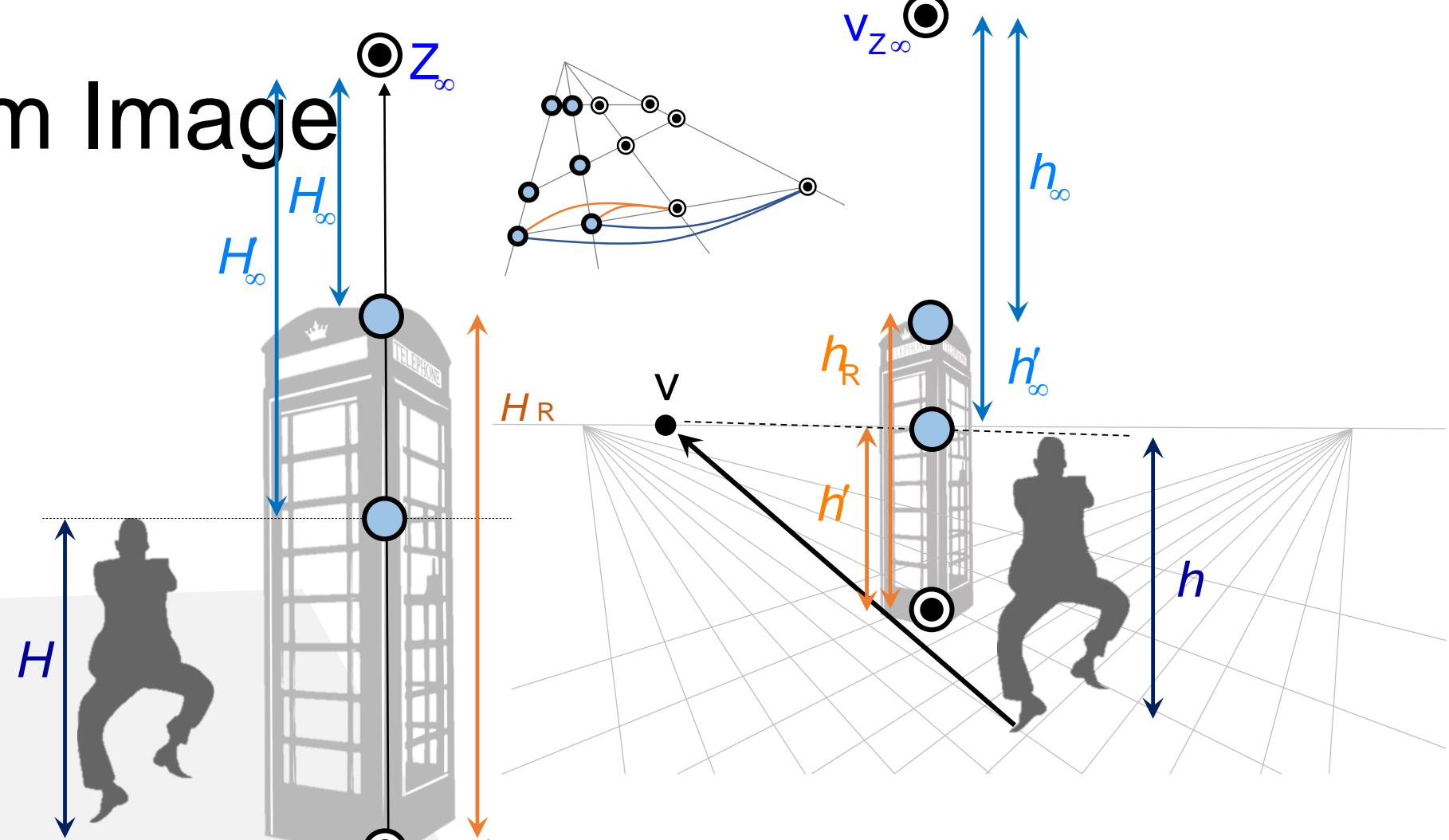
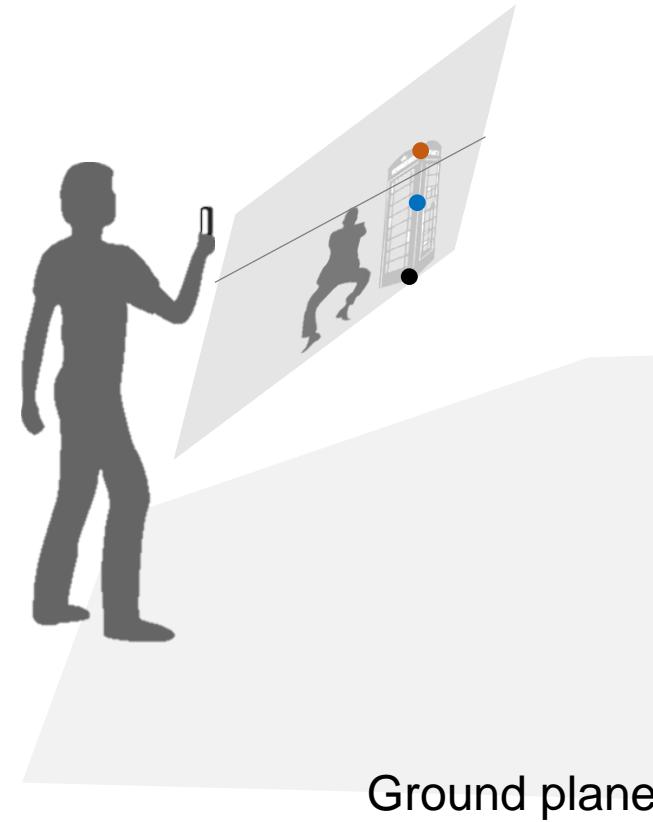
$$\frac{h_R}{h} = \frac{H_R}{H}$$

Height from Image



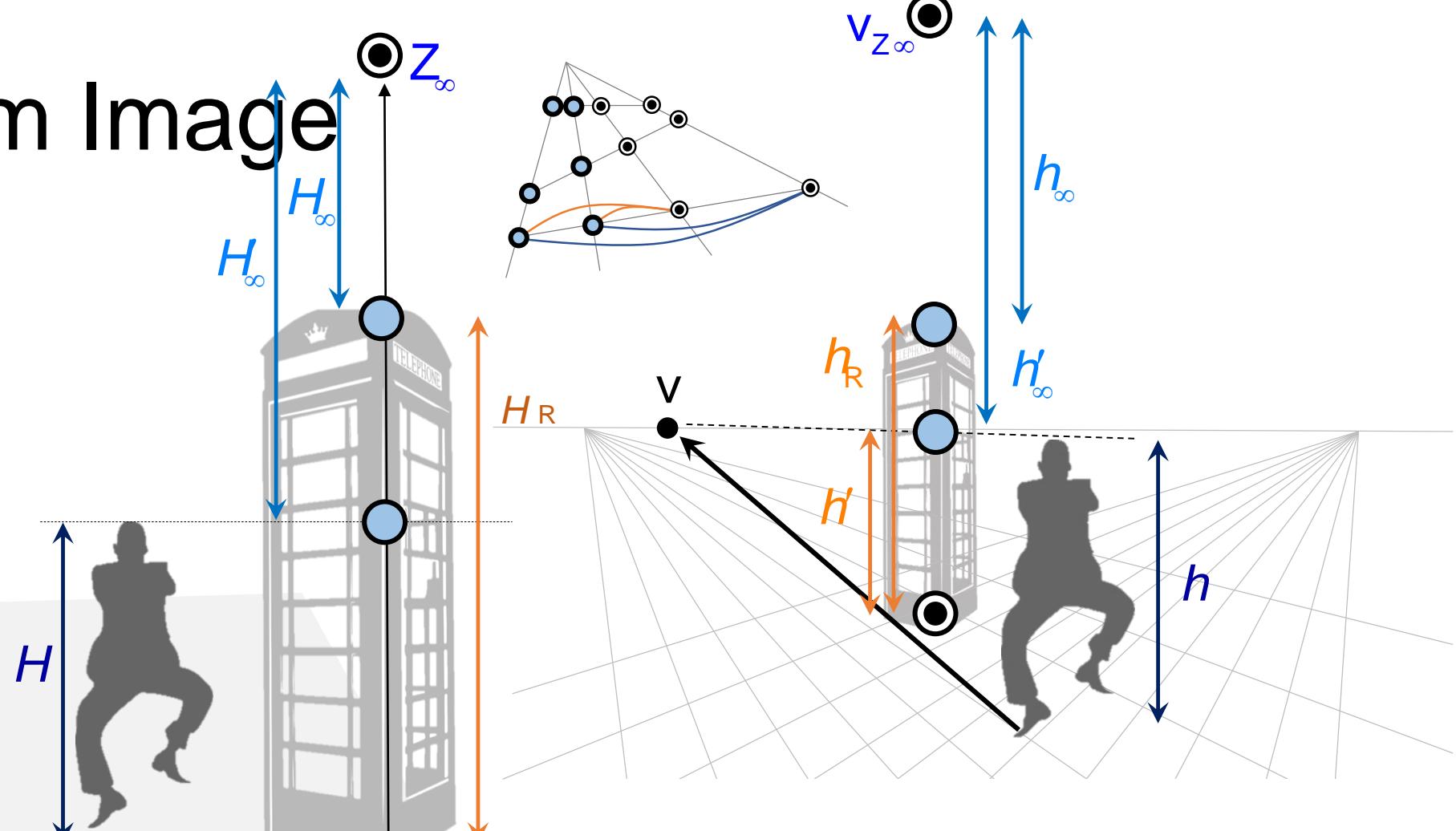
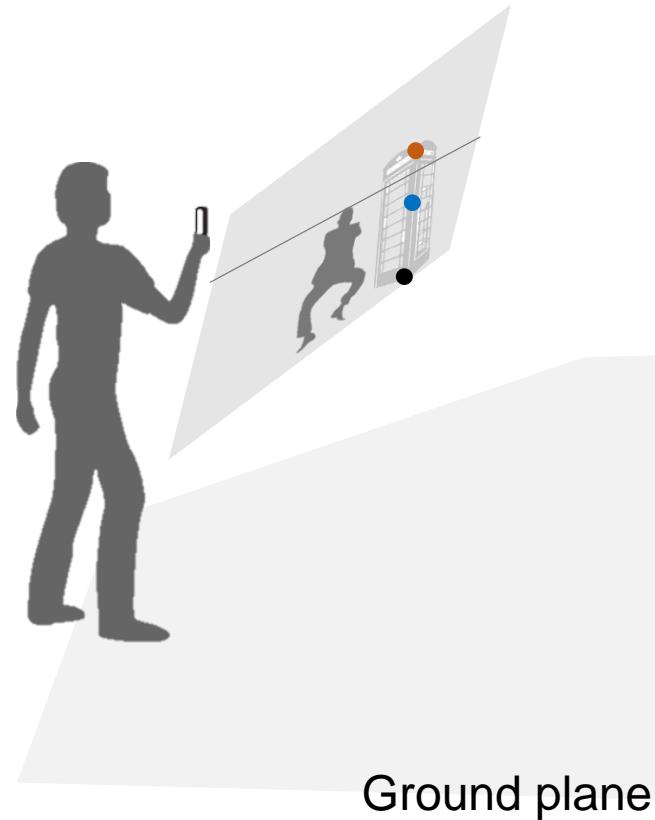
$$\frac{h_R}{h} \frac{h'_\infty}{h_\infty} = \frac{H_R}{H} \frac{H_\infty}{h_\infty}$$

Height from Image



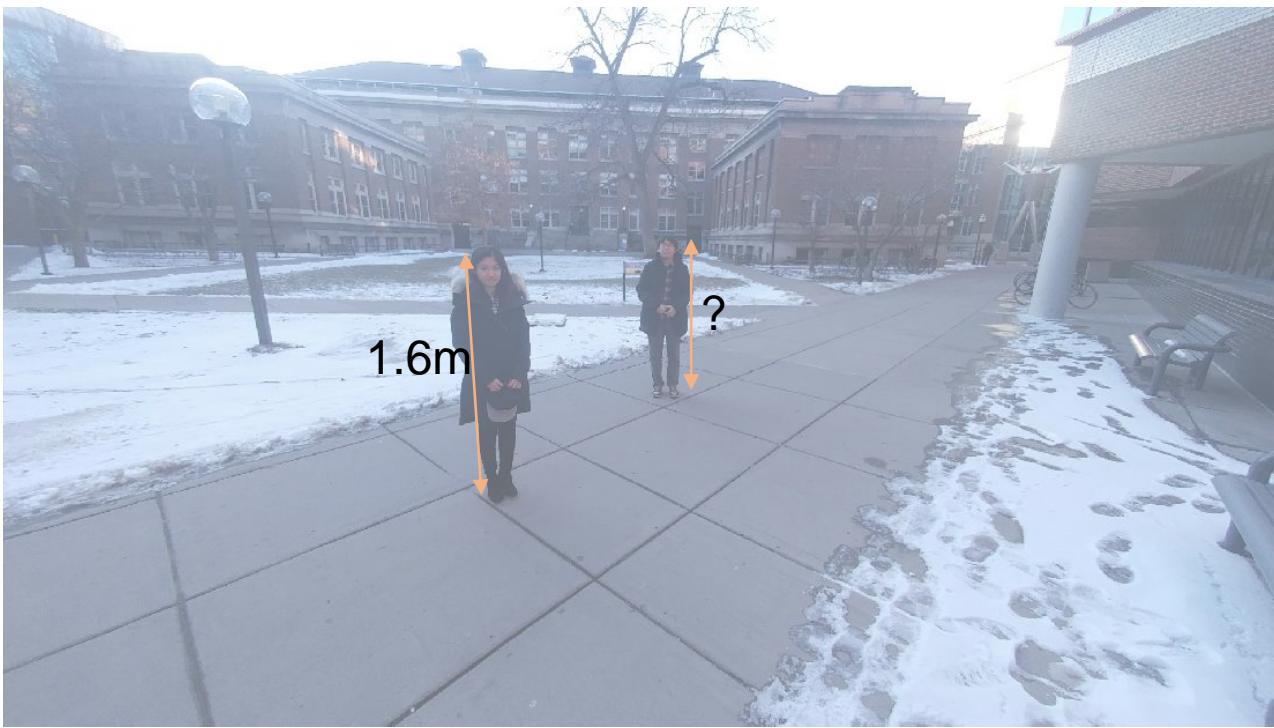
$$\frac{h_R}{h} \frac{h_\infty}{h_\infty} = \frac{H_R}{H} \frac{H_\infty}{H_\infty} = \frac{H_R}{H_\infty} = \frac{H_R}{H}$$

Height from Image

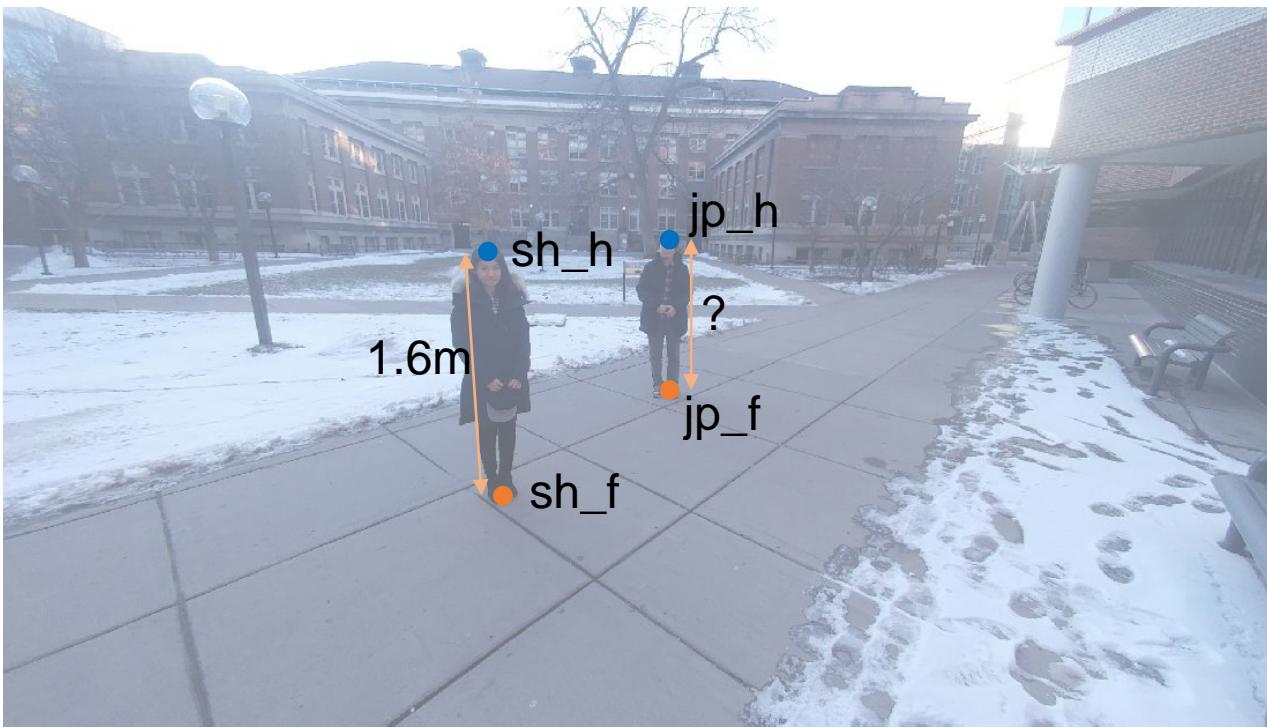


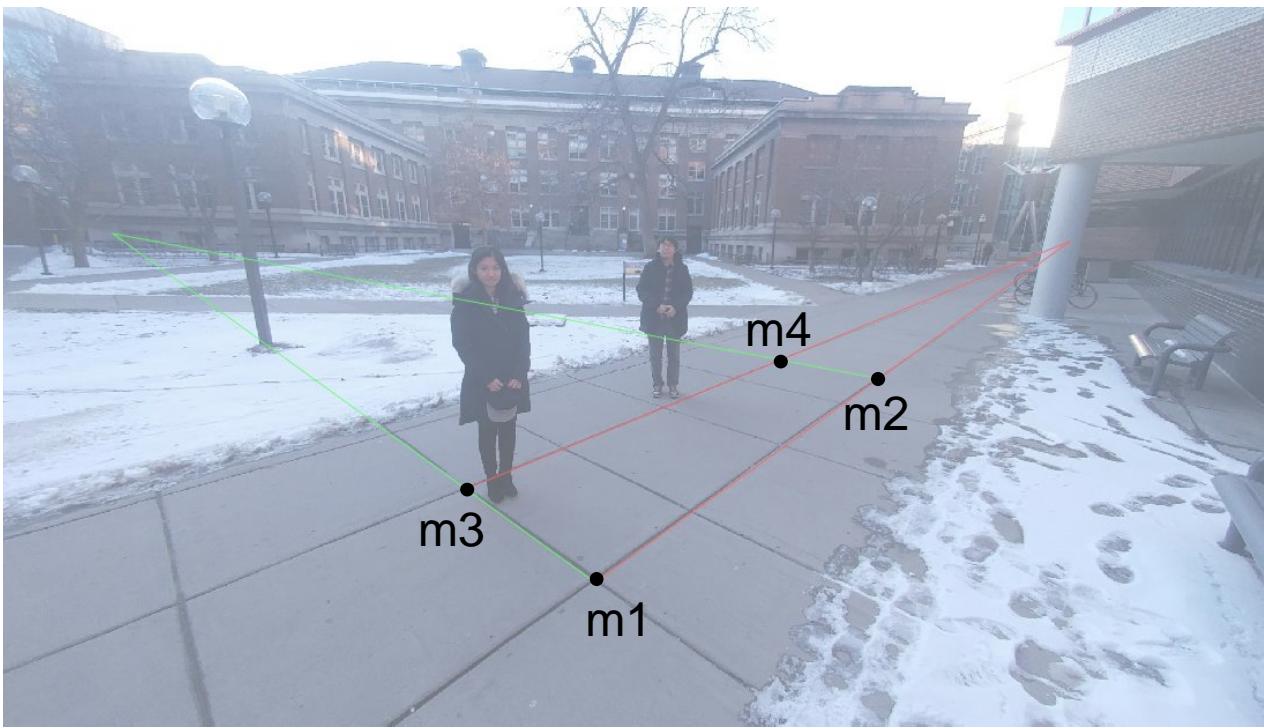
$$\frac{h_R}{H} \frac{H_\infty}{h_\infty} = \frac{H_R}{H} \frac{H_\infty}{H_\infty} = \frac{H_R}{H_\infty} = \frac{H_R}{H}$$

$$\rightarrow H = H_R \frac{h_\infty}{h_R}$$



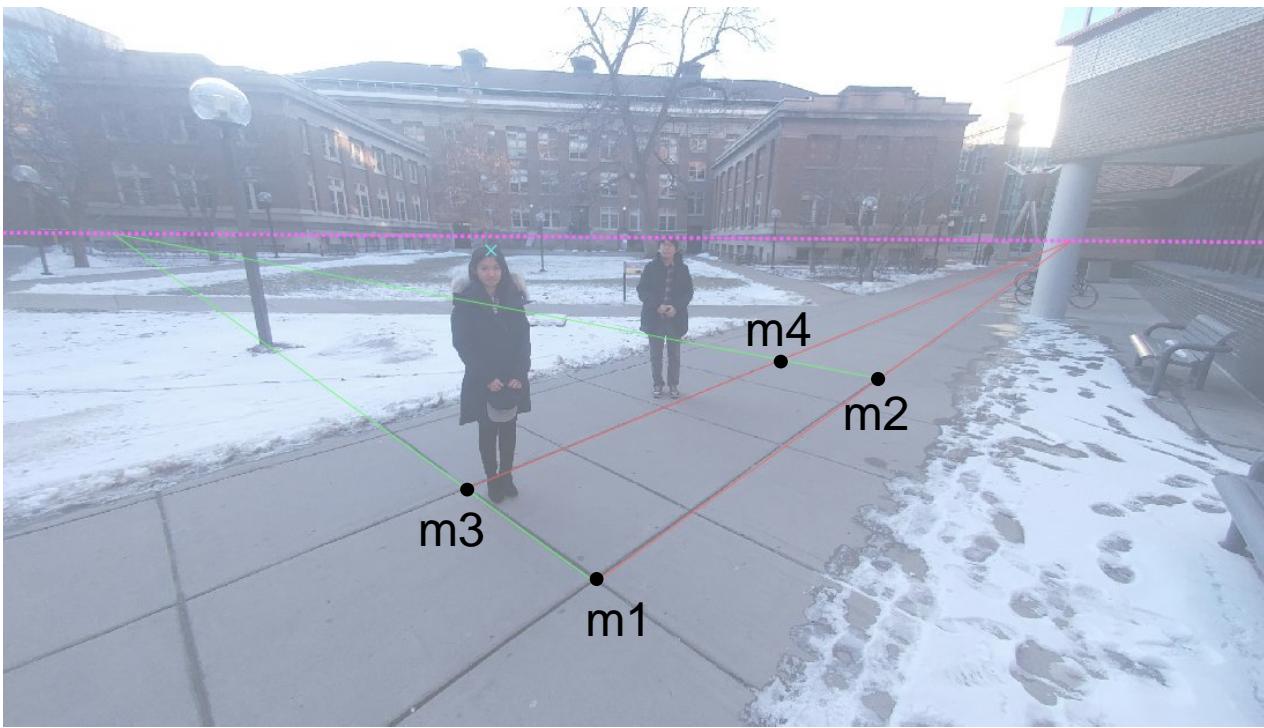
```
sh_f = [1504;1447;1];  
sh_h = [1468;730;1];  
jp_f = [1997;1175;1];  
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```

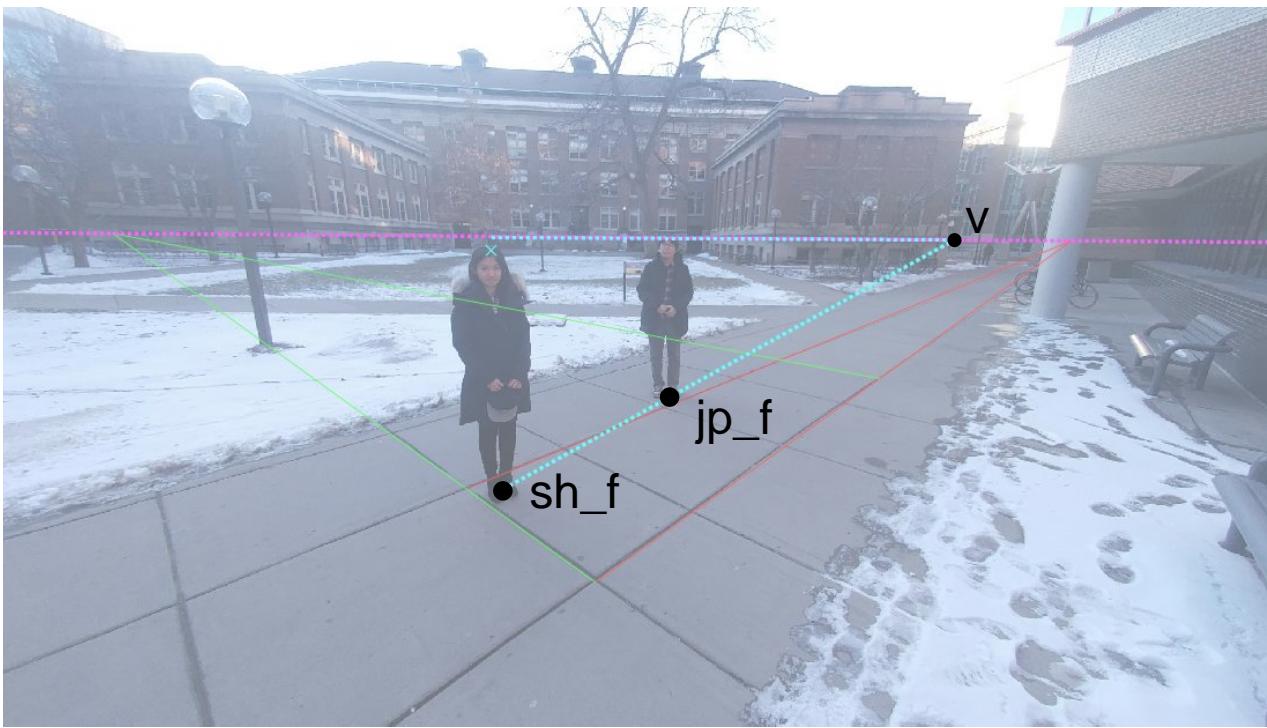


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l = GetLineFromTwoPoints(v1,v2);
```

← Vanishing line



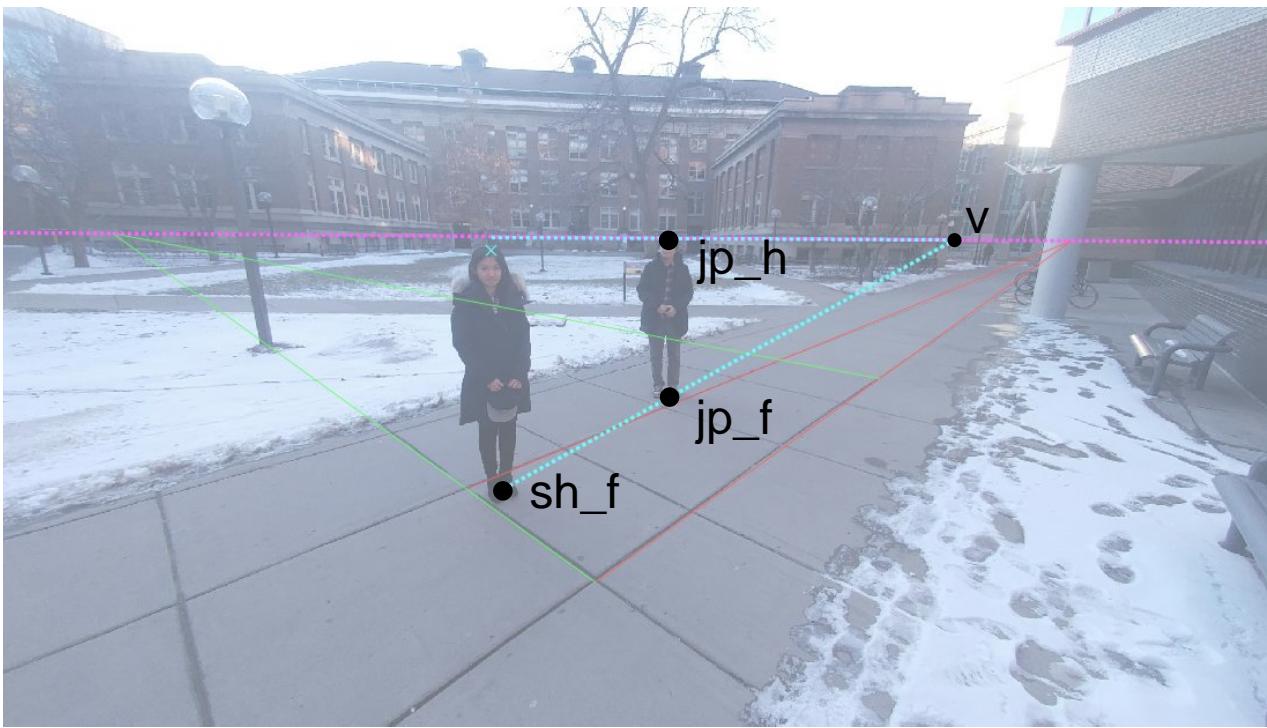
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v1 = GetPointFromTwoLines(l11,l12);  
v2 = GetPointFromTwoLines(l21,l22);  
l = GetLineFromTwoPoints(v1,v2);
```

← Vanishing line

```
line_sh_jp_f = GetLineFromTwoPoints(sh_f,jp_f);  
v = GetPointFromTwoLines(line_sh_jp_f,l);
```



```
sh_f = [1504;1447;1];  
sh_h = [1468;730;1];  
jp_f = [1997;1175;1];  
jp_h = [1997;695;1];
```

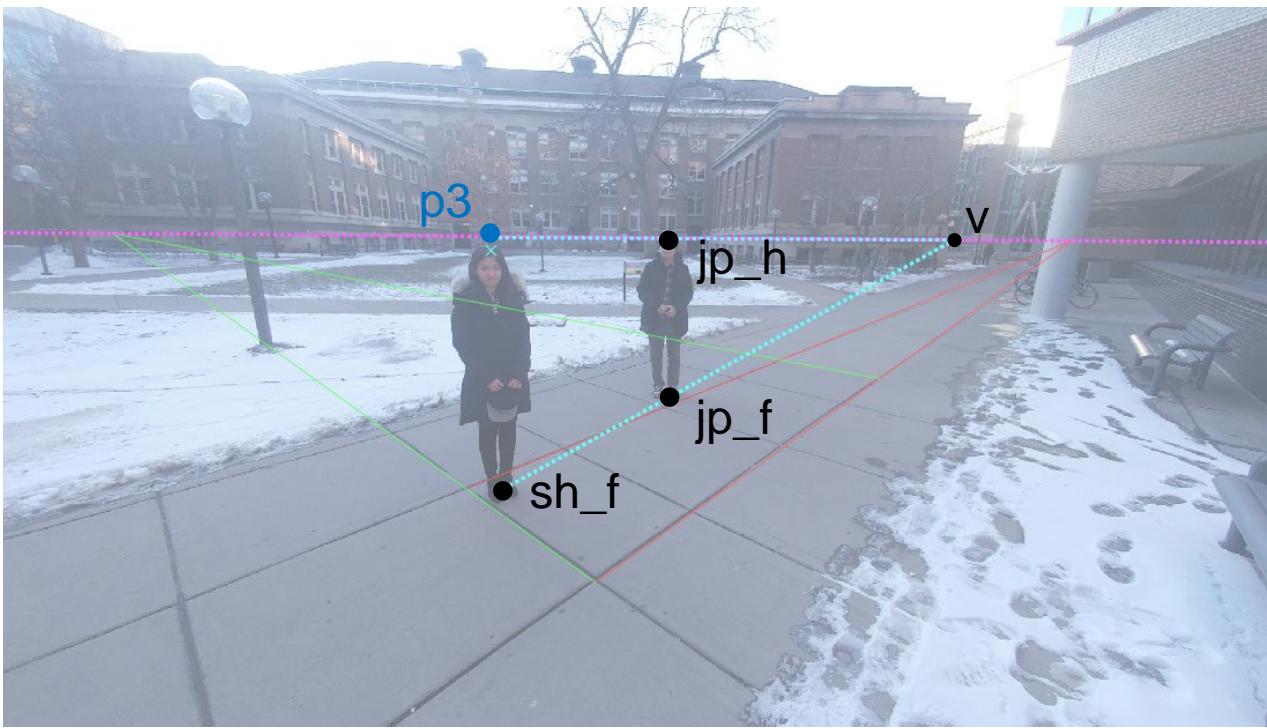
```
l11 = GetLineFromTwoPoints(m1,m2);  
l12 = GetLineFromTwoPoints(m3,m4);  
l21 = GetLineFromTwoPoints(m1,m3);  
l22 = GetLineFromTwoPoints(m2,m4);
```

```
v1 = GetPointFromTwoLines(l11,l12);  
v2 = GetPointFromTwoLines(l21,l22);  
l = GetLineFromTwoPoints(v1,v2);
```

← Vanishing line

```
line_sh_jp_f = GetLineFromTwoPoints(sh_f, jp_f);  
v = GetPointFromTwoLines(line_sh_jp_f, l);
```

```
line_jp_h_v = GetLineFromTwoPoints(jp_head, v);
```



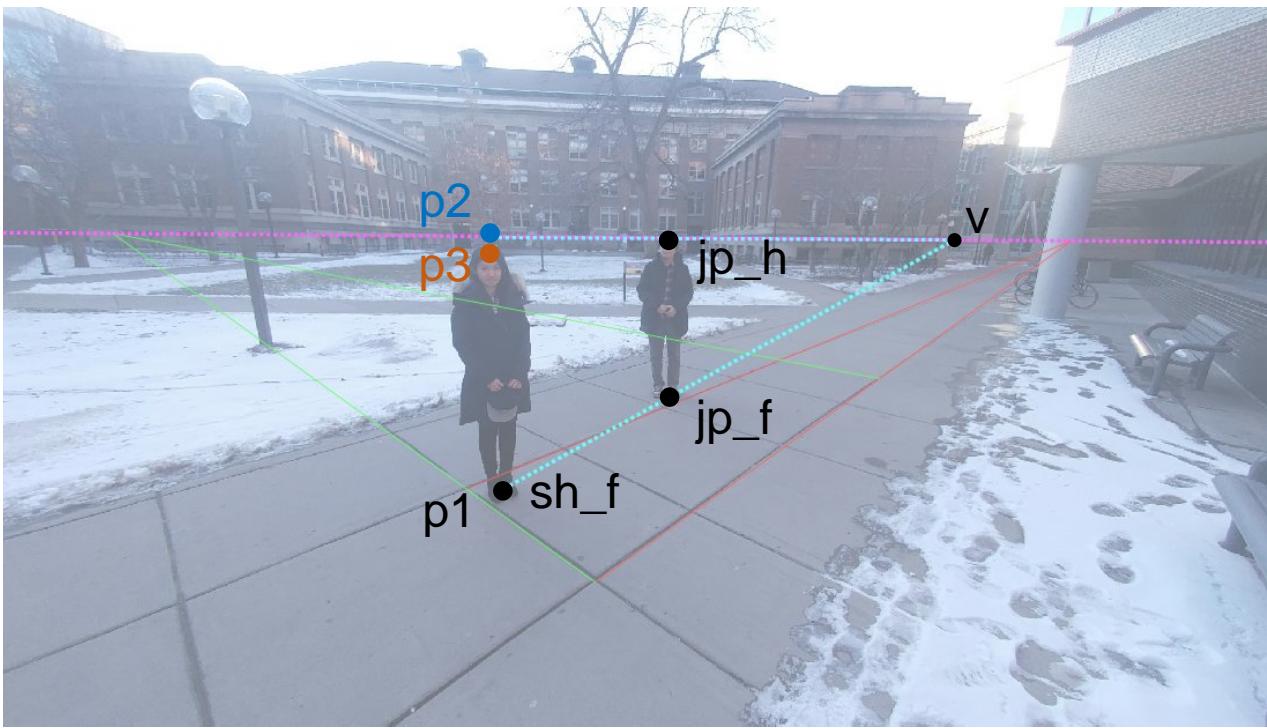
```
sh_f = [1504;1447;1];  
sh_h = [1468;730;1];  
jp_f = [1997;1175;1];  
jp_h = [1997;695;1];
```

```
l11 = GetLineFromTwoPoints(m1,m2);  
l12 = GetLineFromTwoPoints(m3,m4);  
l21 = GetLineFromTwoPoints(m1,m3);  
l22 = GetLineFromTwoPoints(m2,m4);
```

```
v1 = GetPointFromTwoLines(l11,l12);  
v2 = GetPointFromTwoLines(l21,l22);  
l = GetLineFromTwoPoints(v1,v2);
```

← Vanishing line

```
line_sh_jp_f = GetLineFromTwoPoints(sh_f, jp_f);  
v = GetPointFromTwoLines(line_sh_jp_f, l);  
  
line_jp_h_v = GetLineFromTwoPoints(jp_head, v);  
line_sh = GetLineFromTwoPoints(sh_h, sh_f);  
p2 = GetPointFromTwoLines(line_jp_head_v, line_sh);
```



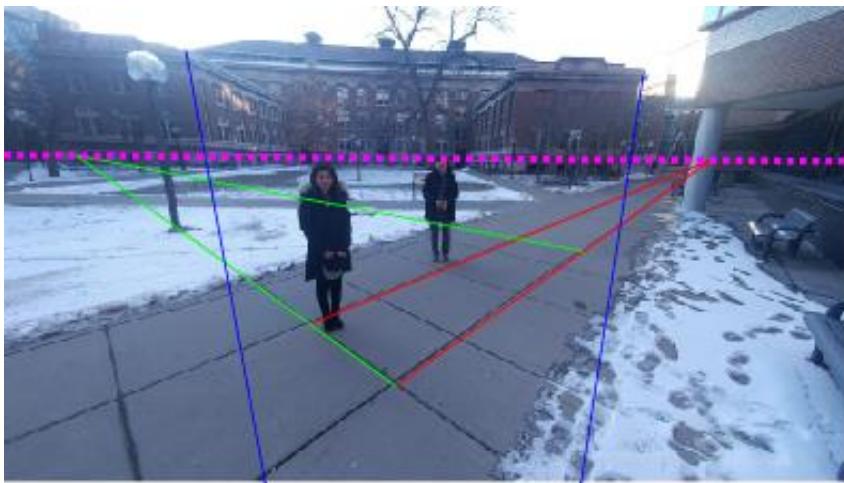
```
sh_f = [1504;1447;1];  
sh_h = [1468;730;1];  
jp_f = [1997;1175;1];  
jp_h = [1997;695;1];
```

```
l11 = GetLineFromTwoPoints(m1,m2);  
l12 = GetLineFromTwoPoints(m3,m4);  
l21 = GetLineFromTwoPoints(m1,m3);  
l22 = GetLineFromTwoPoints(m2,m4);
```

```
v1 = GetPointFromTwoLines(l11,l12);  
v2 = GetPointFromTwoLines(l21,l22);  
l = GetLineFromTwoPoints(v1,v2);
```

← Vanishing line

```
line_sh_jp_f = GetLineFromTwoPoints(sh_f, jp_f);  
v = GetPointFromTwoLines(line_sh_jp_f, l);  
  
line_jp_h_v = GetLineFromTwoPoints(jp_head, v);  
line_sh = GetLineFromTwoPoints(sh_h, sh_f);  
p2 = GetPointFromTwoLines(line_jp_head_v, line_sh);  
p3 = sh_h;  
p1 = sh_f;
```



```
sh_f = [1504;1447;1];  
sh_h = [1468;730;1];  
jp_f = [1997;1175;1];  
jp_h = [1997;695;1];
```

```
l11 = GetLineFromTwoPoints(m1,m2);  
l12 = GetLineFromTwoPoints(m3,m4);  
l21 = GetLineFromTwoPoints(m1,m3);  
l22 = GetLineFromTwoPoints(m2,m4);
```

```
v1 = GetPointFromTwoLines(l11,l12);  
v2 = GetPointFromTwoLines(l21,l22);  
l = GetLineFromTwoPoints(v1,v2);
```

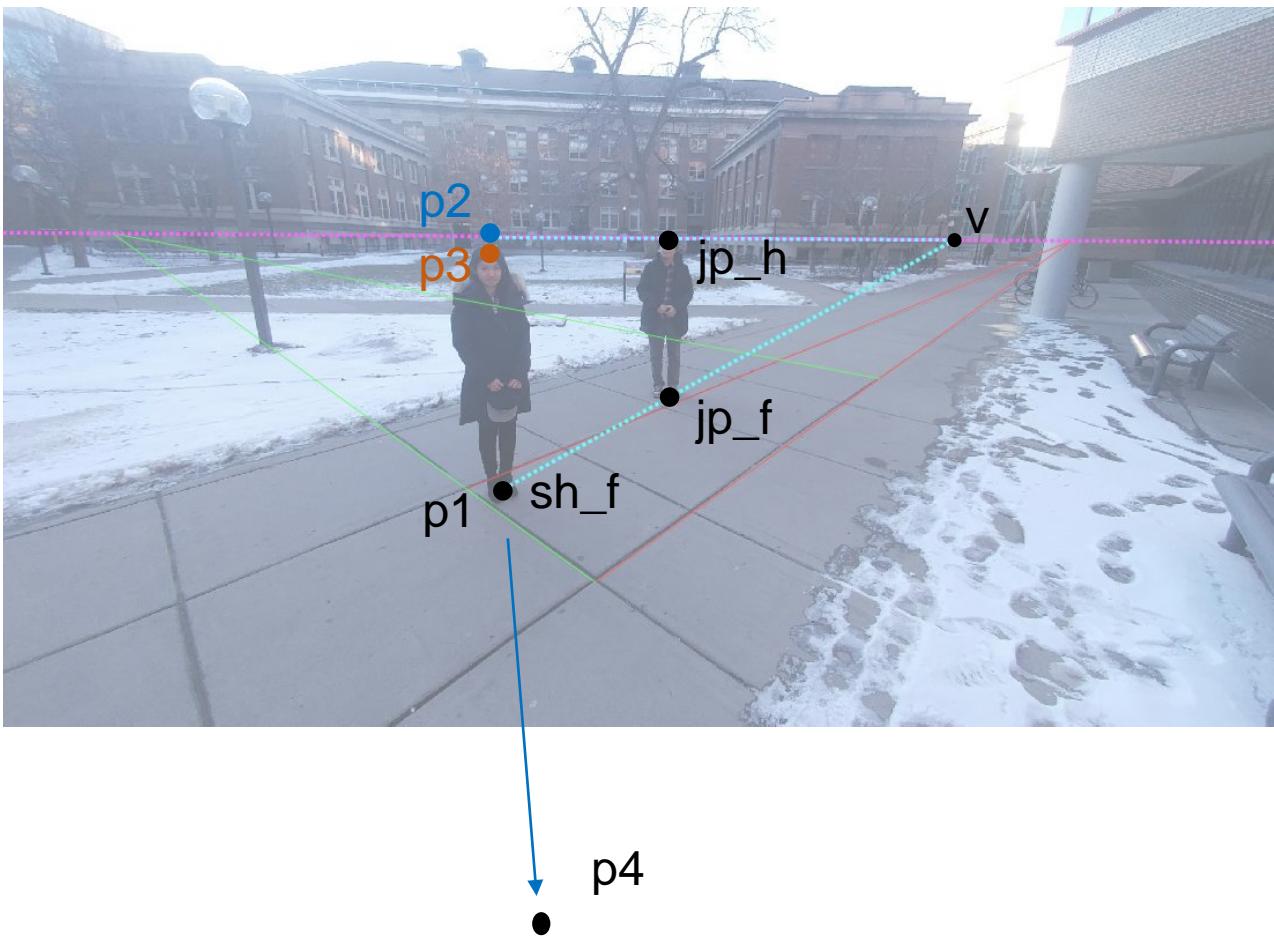
← Vanishing line

```
line_sh_jp_f = GetLineFromTwoPoints(sh_f, jp_f);  
v = GetPointFromTwoLines(line_sh_jp_f, l);  
  
line_jp_h_v = GetLineFromTwoPoints(jp_head, v);  
line_sh = GetLineFromTwoPoints(sh_h, sh_f);  
p3 = GetPointFromTwoLines(line_jp_head_v, line_sh);  
p2 = sh_h;  
p1 = sh_f;
```

```
l31 = GetLineFromTwoPoints(m5,m6);  
l32 = GetLineFromTwoPoints(m7,m8)  
v3 = GetPointFromTwoLines(l31,l32);  
p4 = v3;
```

ComputeHeightFromCrossRatio.m

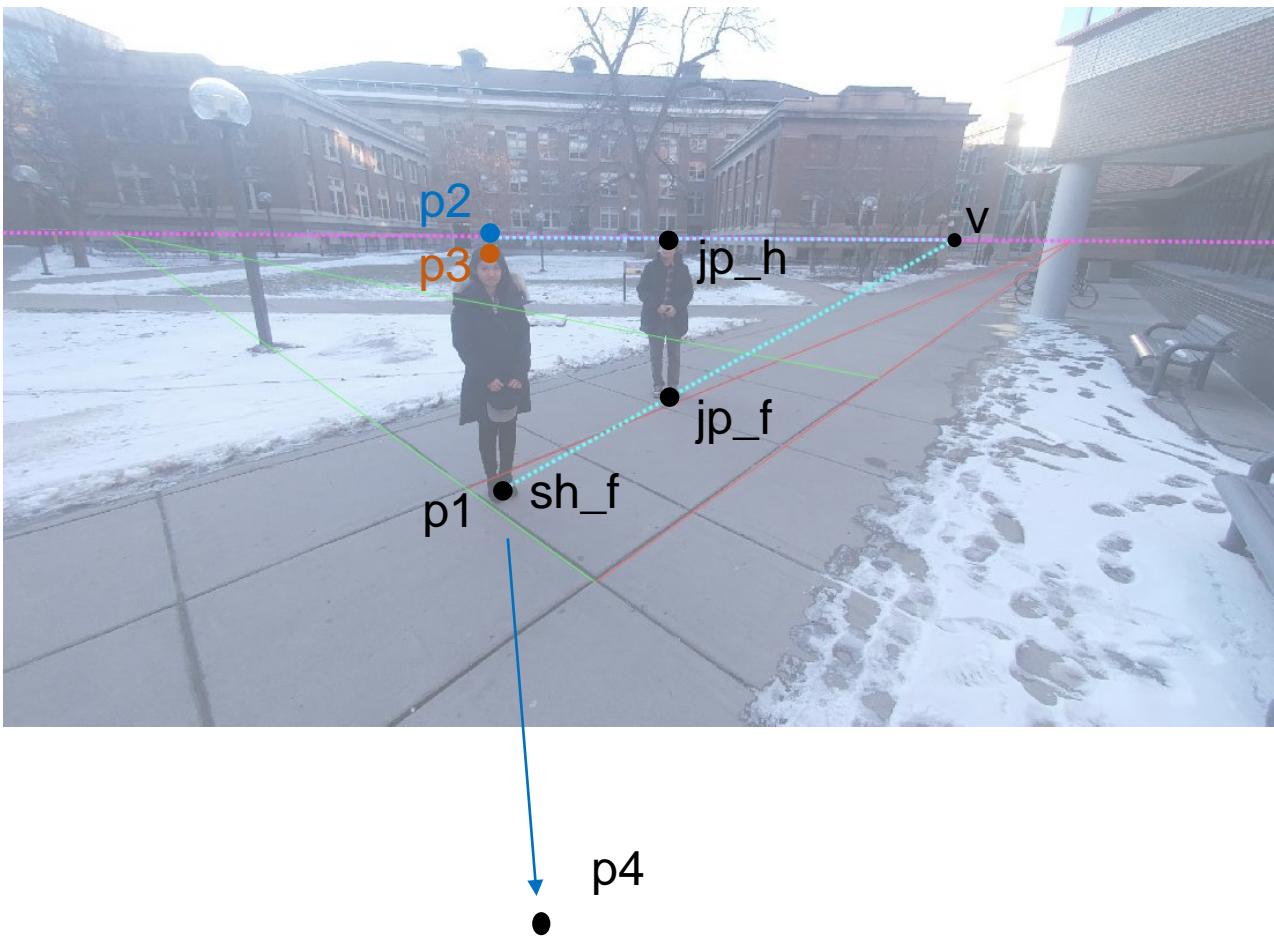
p4



```
h_prime = norm(p1-p2);  
h_R = norm(p1-p3);  
h_prime_inf = norm(p4-p2);  
h_inf = norm(p4-p3);
```

ComputeHeightFromCrossRatio.m

$$H = H_R \frac{h_\infty}{h_R} \frac{h_\infty}{h}$$



```

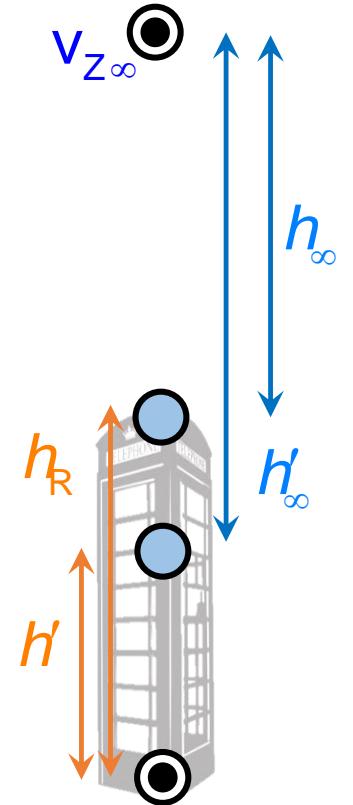
h_prime = norm(p1-p2);
h_R = norm(p1-p3);
h_prime_inf = norm(p4-p2);
h_inf = norm(p4-p3);

```

$$H = H_R * h_{\text{prime}} * h_{\text{prime_inf}} / h_R / h_{\text{inf}}$$

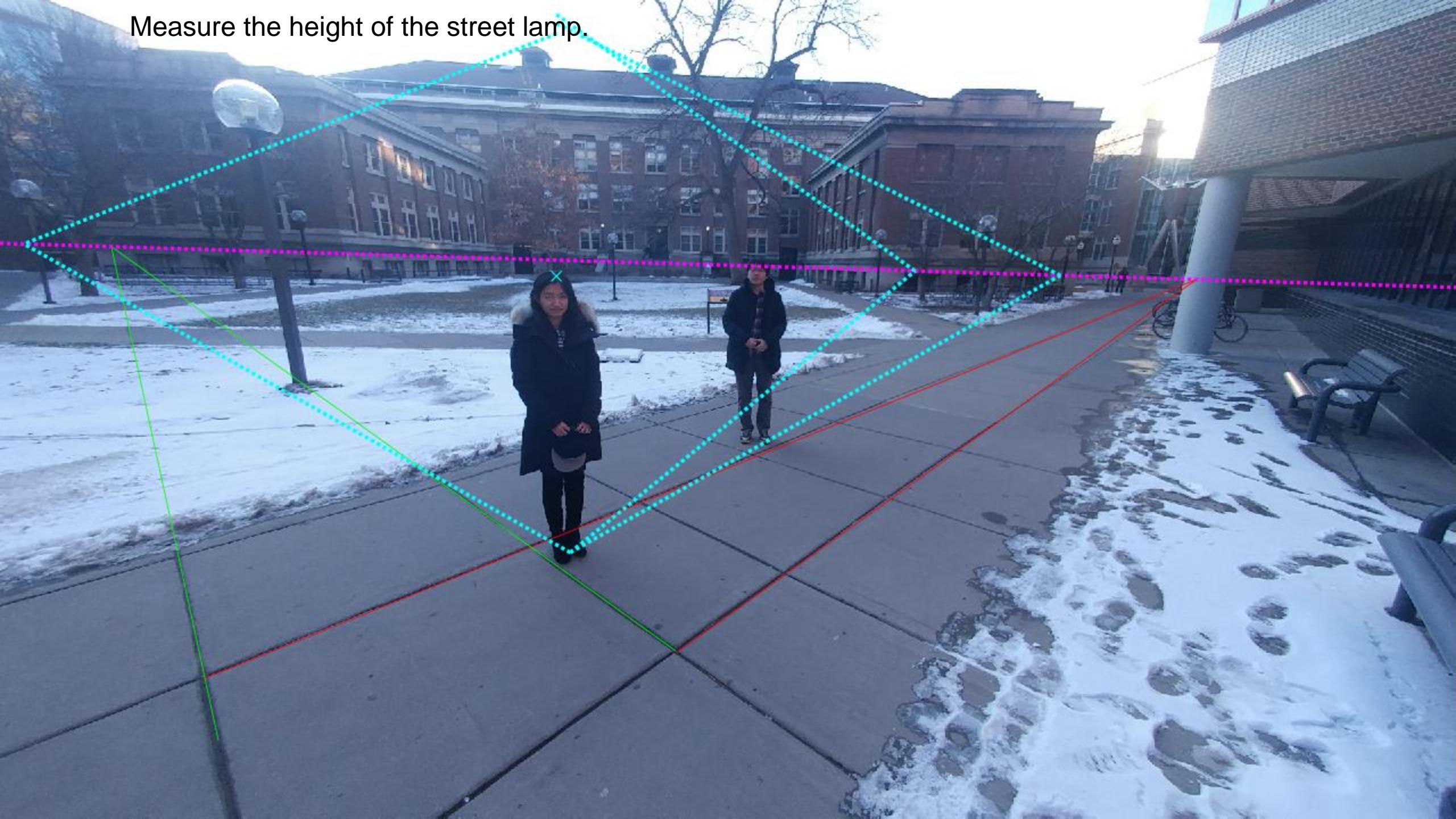
$H =$
1.6779 Ground truth: 1.7m

$$H = H_R \frac{h_{\infty}}{h_R h_{\infty}}$$



ComputeHeightFromCrossRatio.m

Measure the height of the street lamp.



Measure the height of the street lamp.

$H = 2.8108m$

