← Back

QUIZ 1

Practice Assignment

English

basically just means taking a filter (matrix) and applying it at different parts of an image (another matrix)

1. Performing convolution requires (size of kernel)x(size of kernel) multiplications and additions per pixel. Assuming a 8 x 8 separable kernel into one-dimensional horizontal and vertical kernels, what would be the theoretical speedup of performing a separable convolution? 1 point

filter...

So... instead of using 1 8x8 matrix to multiply, it is faster if we can use two 1-D matrices... 4 by 1 and 1 by 4. I imagine a 3x3 ...

- (●) 4
- ( ) 2
- ( ) 1.5
- ( ) 3

one larger filter = $O(n^2)$ 2 filters
2 smaller, 1-D ones = $O(n)$
So with $n=8$ ... $O(8^2)$ vs $O(2 \cdot 8)$
64 = (16) (4)

2. If "**f**" represents linear filtering operation, c is a scalar constant and we want to apply the filter **X** to two images **Y** and **Z** which of the following is equivalent to: 1 point

f(X, cY) + f(X, Z)

↳ linear filtering operation of applying filter X to image Y (times c) + applying X to Z

- ( ) c f(cX, cY + cZ)
- (●) f(X, cY + Z)
- ( ) c f(X, Y + Z)
- ( ) f(cX, cY + cZ) *

with linear filtering, we have some key properties: see definitions in notes
- linearity
- shift invariance
- commutative - distributes over addition - scalars factor out
- associative

this is linearity: filtering the sum is the same filtering separately and then adding

3. For which of the following values of (a, b, c, d, e, f, g, h and i) does the following filter correspond to a high-pass filter? 1 point

3. For which of the following values of (a, b, c, d, e, f, g, h and i) does the following filter correspond to a high-pass filter? **1 point**

a	b	c
d	e	f
g	h	i

↳ keeps high frequencies while not keeping low ones...

The negative weights will cause the retained pixel value to regard even less for its neighbors. Thus, if the pixel is very different than its neighbors, the 3x on it and $-\frac{1}{9}$ on everything else will make this clear. if the pixels are all quite similar... then doing 3x on the pixel would be similar to doing 3x on any other pixel in the neighborhood.

- ○ a = 0, b = 1, c = 0, d = 1, e = 0, f = 1, g = 0, h = 1, i = 0
- ○ a = 1/9, b = 1/9, c = 1/9, d = 1/9, e = 1/9, f = 1/9, g = 1/9, h = 1/9, i = 1/9
- ○ a = 1/8, b = 2/8, c = 1/8, d = 2/8, e = 4/8, f = 2/8, g = 1/8, h = 2/8, i = 1/8
- ◉ a = -1/4, b = -1/4, c = -1/4, d = -1/4, e = 12/4, f = -1/4, g = -1/4, h = -1/4, i = -1/4

4. Which of the following holds true? **1 point**

0	1/8	0
1/8	1/2	1/8
0	1/8	0

why? How does this filter retain the low frequencies but not high? well, high frequencies = sharp changes/transitions which means difference in neighboring pixels.

Thus, any filter that will filter by taking more of an average of the neighborhood, as opposed to increasing variation, will be a low pass filter.

- ◉ The filter is a low-pass filter.
- ○ The filter evenly removes both high frequencies and low frequencies.
- ○ The filter is a high-pass filter.

- ○ The preserved frequencies depend on the input.

frequency changes

5. The edges and grainy parts of an image correspond to: 1 point

because the Fourier transform image takes something like an edge has high freq. This is because there is a change in intensities.

- ◉ High-frequency components of a Fourier transform image.
- ○ Low-frequency components of a Fourier transform image.
- ○ The responses closer to the center (0,0) of a Fourier transform image.
- ○ None of the above

6. Which part of the frequency spectrum has the most power for natural images? 1 point

- ○ It varies from image to image
- ○ Mid frequencies
- ○ High frequencies
- ◉ Low frequencies

"images are mostly smooth"
- there is not a lot of change in intensity from pixel to pixel
- thus.. we can keep most of the image information with just low freqs.

7. Which of the following is ***not*** true about the Fourier transform? 1 point

- ○ Provides a different view of filters that is sometimes easier to interpret ✓
- ○ Preserves the energy in the image ✓
- ◉ Adds information to the image
- ○ Can be used to improve the speed of linear filtering ✓

← Back

Practice Quiz 3.1.2 : How Light is Reflected From a Surface

Practice Assignment

English

1. **One of the most basic ways to model light's reflection on a surface is as a/an _____, where some incident light is _____ and the rest is _____.** 1 point

- ○ Lambertian model, absorbed, specularly reflected
- ○ Specular model, absorbed, diffusely reflected.
- ○ Lens model, reflected, refracted
- ◉ Lambertian model, absorbed, diffusely reflected
- ○ None of the above

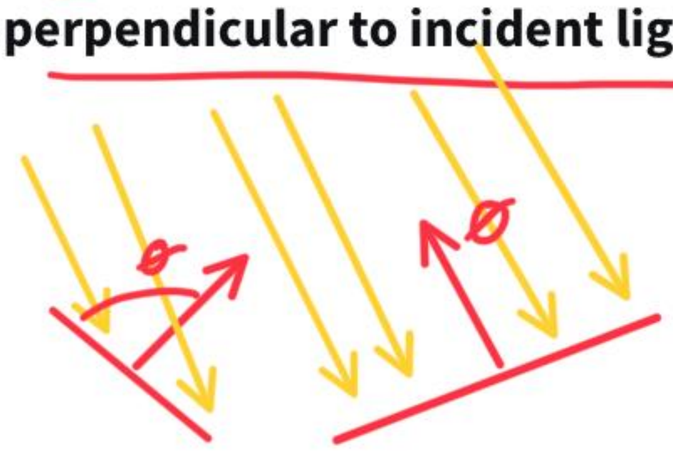
taken straight from notes. Review week 3.

2. **True or False : The intensity of the light reflected from a lambertian surface whose normal is perpendicular to incident light rays is *maximum*.** 1 point

brightness

minimum (0)

- ○ True
- ◉ False



"if S and N are in the same direction you maximize the dot product"

$I(x) = \rho(x)(S \cdot N(x))$

$I(x)$: intensity of x

$\rho(x)$: albedo (% of light reflected at x)

S: orientation / strength of light

$N(x)$: normal of surface (direction perpendicular to the surface)

3. **Select the True statements.** 1 point

- ☑ Blushing is a phenomenon owing to increased subsurface scattering of red light.
- ☐ Reflection of light of a different wavelength than the incident light is known as *phosphorescence.*
- ☑ Specular reflection is responsible for glare in the rear view mirror.

↳ think "mirror"

- ☐ The intensity of light reflected off of an indoor carpet depends on your angle of viewing.

No. This is not how light works.

"The perceived intensity does not depend on the viewer angle"

← Back

Practice Quiz 3.1.2 : How Light is Reflected From a Surface

Practice Assignment

English

of viewing.

4. **True of False? Computers can interpret the albedo (true color) of an object much better than humans can.** 1 point

- ○ True
- ◉ False

because color channels don't actually have all colors

5. **If a point is not in light of sight to a light source, then it is in _____.** 1 point

- ○ the dark
- ✓ ◉ shadow
- ○ the occluder
- ○ the point source

see definitions

6. **Every object is an indirect light source for every other object in a scene because of _____.** 1 point

- ○ shadows
- ○ color illusions
- ○ albedo
- ◉ inter-reflections
- ○ None of the above

light bouncing off of other objects in the scene

Practice Quiz 3.1.1 : How Light is Measured

Practice Assignment

← Back

English

1. **In the human eye, the pupil is the aperture whose size is controlled by the iris.** 1 point

- Lens, Cornea
- Retina, Annulus
- Iris, Pupil
- Pupil, Iris
- None of the above

pupil → controls how much light gets in

2. **The rod cells are highly light-sensitive receptors in the retina that operate at night, and are responsible for gray-scale vision.** 1 point

- Ganglion, night vision
- Cone, color vision
- Rod, color vision
- Cone, gray-scale vision
- Rod, gray-scale vision

See notes from WEEK 3 for all information on the physics / physiology of eyes / light

3. **Which of the following statements is *False*?** 1 point

- Cone cells, which are responsible for color-vision, are more sensitive outside the center of vision, which is why there are more stars visible off center.
- The distribution of cone cells spikes at the center of the eye, which results in

← Back

Practice Quiz 3.1.1 : How Light is Measured

Practice Assignment

English

3. Which of the following statements is *False*? 1 point

- Cone cells, which are responsible for color-vision, are more sensitive outside the center of vision, which is why there are more stars visible off center. ~0.2 cells are here
- The distribution of cone cells spikes at the center of the eye, which results in a small range of angles where we have extremely high resolution vision. about the size of a finger nail...?
- Rod cells, which are responsible for gray-scale vision are more sensitive outside the center of vision, which is why shooting stars in the night sky may seem more visible off center.
- The distribution of rod cells is lowest at the blind spot, about 20 degrees from the center of vision.

4. Which of the following statements is True? 1 point

- The genes for the "M" and "L" cones are on the ~~Y~~ X chromosome.
- Humans perceive light in terms of Red, Green, and Blue corresponding to the "L", "M" and "S" cones.
  ↳ wrong because color is perceived on a spectrum: the cones do not directly map to these colors
- The Bayer grid has more red cells because our eyes have more cells sensitive ~~to red light~~.
  ↳ used in digital imaging sensors in cameras → we actually have more green
- The CIE-XYZ color space is used as a basis for other color spaces.
- None of the above

← Back

Practice Quiz 3.2.1 : Color Spaces

Practice Assignment

English

1. A color space is perceptually uniform if (Select one) : 1 point

- ○ Colors are uniformly distributed in the vector space.
- ◉ Small distance in the vector space corresponds roughly to distance in the perceptual space, which can be gauged through experimentation. → asking people to tune a color to match 2 others`
- ○ If two vectors are the same distance from the origin, they are the same color.
- ○ None of the above

2. Which of the following color spaces show perceptual uniformity? 1 point

- ○ HSV
- ○ XYZ
- ○ RGB
- ◉ LAB → how LAB was made

3. Shadows on a sunny day may appear blue in a chrominance image (LAB space image without the luminance channel) because : 1 point

- ○ Areas in shadow have generally lower temperature than those in direct light, and thus appear blue in a chrominance map.
- ○ There is no black in the chrominance channels of an LAB image, so whatever is dark appears blue.
- ◉ The lighting outdoors can be modelled as a combination of direct sunlight and scattered blue light from the sky. Since shadows are devoid of direct yellow sunlight they appear blue.
- ○ All of the above

- RGB
- LAB

3. **Shadows on a sunny day may appear blue in a chrominance image (LAB space image without the luminance channel) because :** 1 point

- Areas in shadow have generally lower temperature than those in direct light, and thus appear blue in a chrominance map.
- There is no black in the chrominance channels of an LAB image, so whatever is dark appears blue.
- The lighting outdoors can be modelled as a combination of direct sunlight and scattered blue light from the sky. Since shadows are devoid of direct yellow sunlight they appear blue.
- All of the above

4. **Suppose you are trying to make the colors in an image more vivid. What color space might you transform the image into in order to most easily effectively achieve this and how would you do it?** 1 point

- LAB, and then adjust the *a* and *b* channels
- XYZ, increase values in all channels
- HSV, increase the values in the Value channel
- HSV, increase the values in the Saturation channel
- Any of the above

← Back

Practice Quiz 3.2.2: Color Balancing

Practice Assignment

English

1. **When performing color balancing via linear adjustment or similar method, it is sometimes helpful to use the "gray world" assumption. What is this and why is it helpful?** 1 point

- ○ It is the assumption that color is just in the mind, and that the real world is gray. It reveals that there is no point in doing color balancing in the first place.
- ○ It is the assumption that driving all the colors toward gray will result in the most realistic color balanced picture. It allows you to choose constants such that the balanced picture looks as gray as possible.
- ◉ The assumption that the average color in a picture *is* gray, and therefore allows you to choose constants for each channel as the average of all the pixels in the image divided by the channelwise average.
- ○ The assumption that improperly color balanced images are a result of too much gray in the image. It allows you to choose constants that maximize the amount of gray removed from the image.
- ○ None of the above

2. **You tone-mapped using the Global (Reinhart) transformation. What was the world luminance of a pixel whose display luminance 0.995 (up to 3 significant figures)?** 1 point

- ○ 0.498
- ◉ 199
- ○ 1.498
- ○ 200
- ○ None of the above

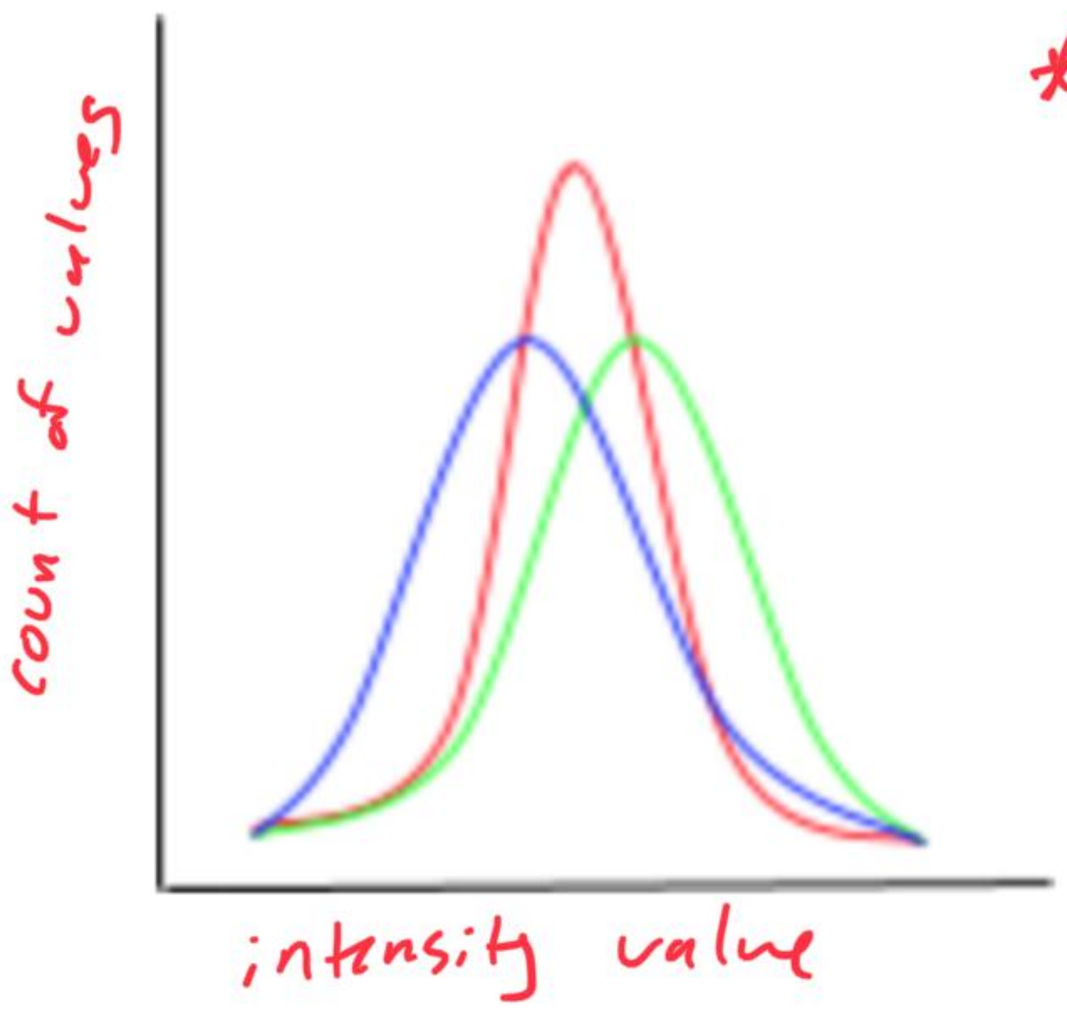
$$L_{display} = \frac{L_{world}}{1 + L_{world}}$$

"take the luminance in the world divided by 1 + luminance in the world"
- really compresses bright values, less so darker ones

$$.995 = \frac{199}{1+199} = .995$$

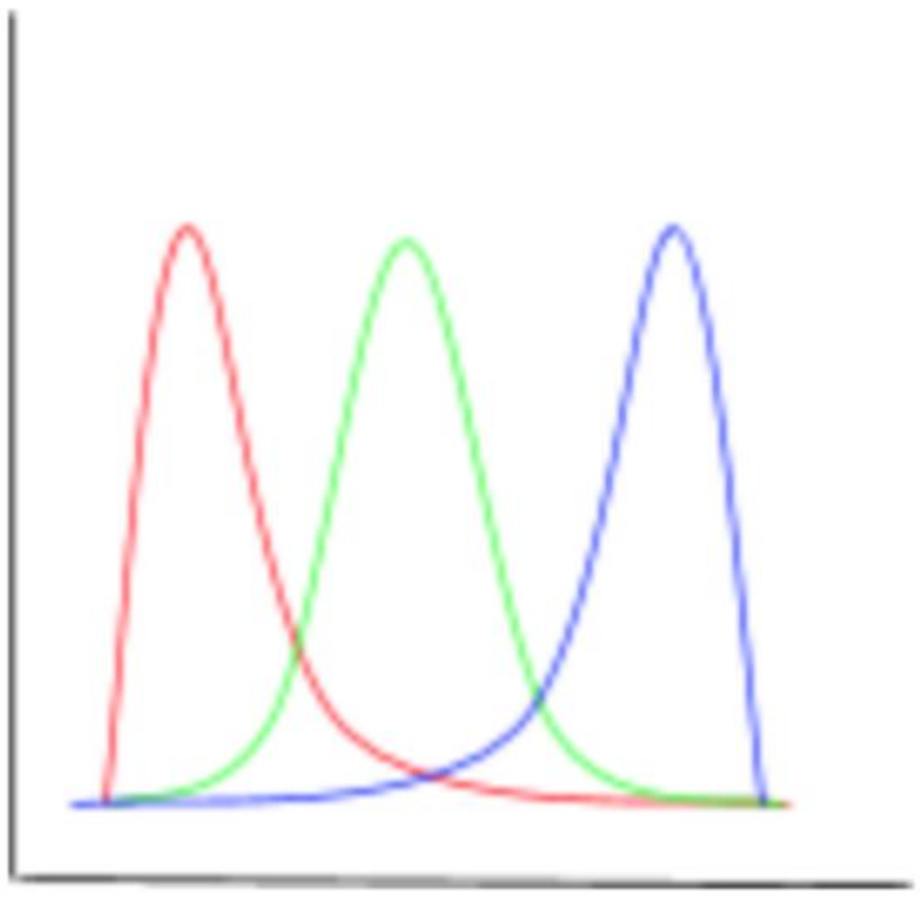
3. **Which of the following histograms of red, green and blue channels represent a more color balanced image?** 1 point

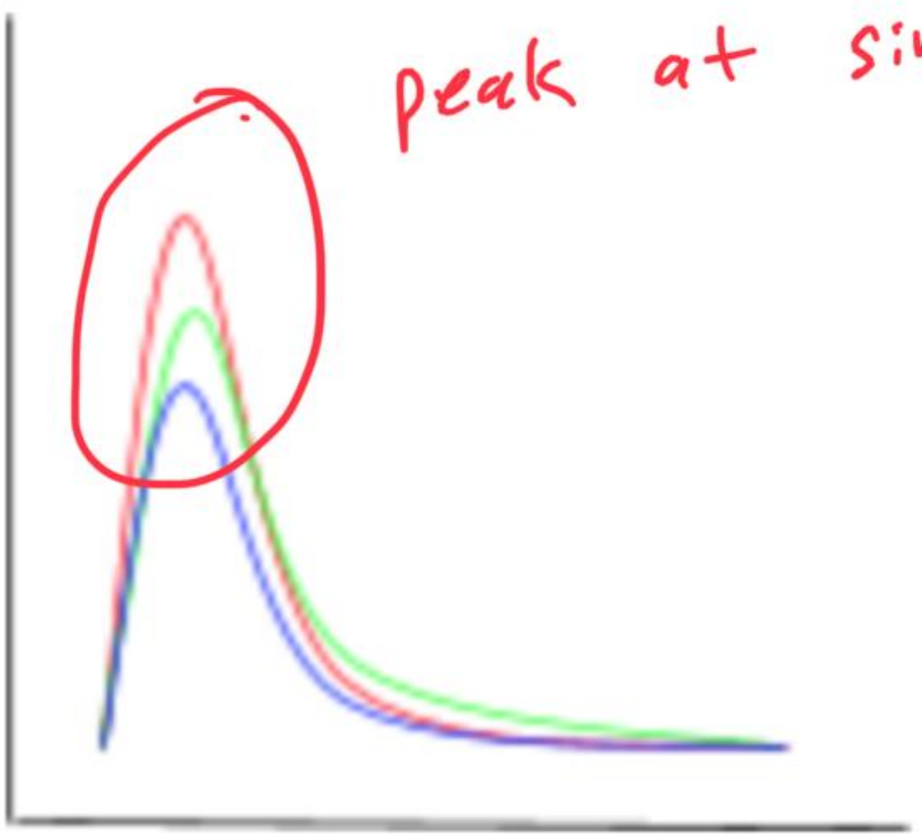
○

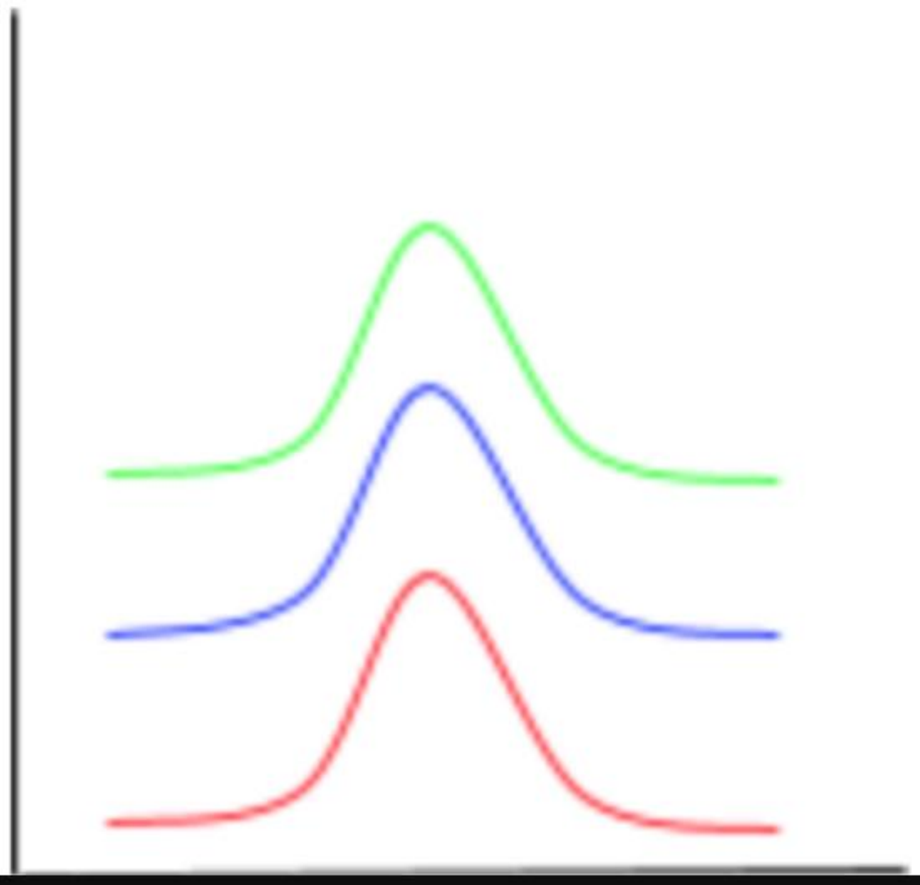


* A balanced image will have all 3 channels peaking at a similar intensity value.

○




peak at similar intensity value



← Back

Practice Quiz 3.2.3 : Histogram Equalization

Practice Assignment

English

1. If H = hist(A, 1:6) = [3,0,1,1,2,2]. Which of the following could be A? 1 point

1 2 3 4 5 6

- [ ] [3,1,1,1,4,4,5,6,6]
- [ ] [1,3,5,1,5,4,6,1,2]
- [x] [1,4,5,1,1,5,6,3,6]
- [x] [1,3,4,6,1,5,1,5,6]

3 1's, 2 0's, etc... same here

2. In order to prevent color shift **during histogram equalization of a/an, it is best to split the image into** luminance/Chrominance **channels. (Choose the best pair).** 1 point

- ○ Blurring, hue and saturation
- ○ Color shift, hue and saturation
- ○ Block (JPEG compression) artifacts, RGB
- ◉ Color shift, luminance and chrominance
- ○ None of the above

by separating the brightness from the color of the image, we can alter the brightness independent of the color.

Skip

← Back

Practice Quiz 4.1

Practice Assignment • 1h

English

1. **Choose the patch most similar to the following patch. Use SSD as your measure of similarity.** 1 point

[[1 , 2],

[2 , 1]]

Sum of squared differences ...

- [[1, -2],
  [-2, 1]]

$$\begin{bmatrix} 1 & 2 \\ 2 & 1 \end{bmatrix} \begin{bmatrix} 1 & -2 \\ -2 & 1 \end{bmatrix}$$

$$0^2 + 4^2 + 4^2 + 6^2 = 32$$

- [[2, 1],
  [-1, 2]]

$$\begin{bmatrix} 2 & 1 \\ -1 & 2 \end{bmatrix} \begin{bmatrix} 1 & 2 \\ 2 & 1 \end{bmatrix}$$

$$1^2 + 1^2 + 3^2 + 1^2 = 12$$

- [[-1, -2],
  [-2, -1]]

$$\begin{bmatrix} -1 & -2 \\ -2 & -1 \end{bmatrix} \begin{bmatrix} 1 & 2 \\ 2 & 1 \end{bmatrix}$$

$$2^2 + 4^2 + 4^2 + 2^2 = 40$$

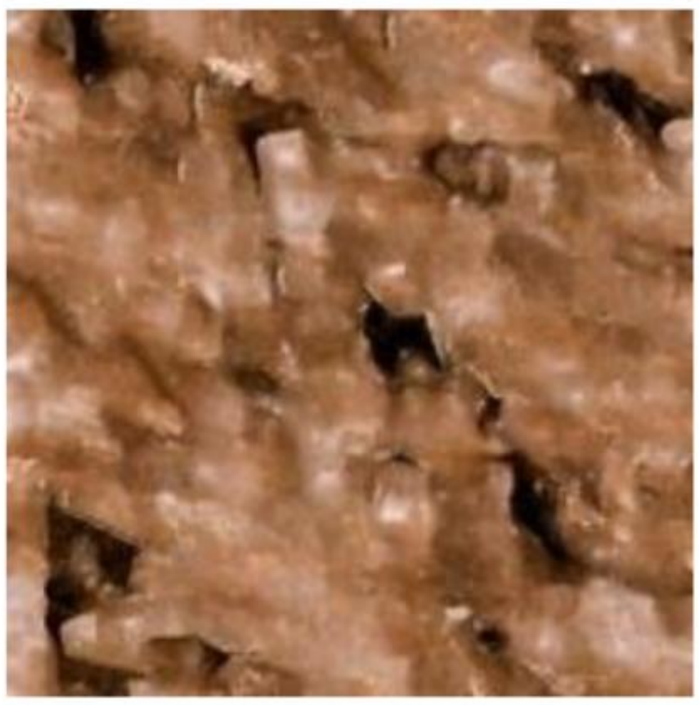
- [[0 , 3],
  [3, 0]]

$$\begin{bmatrix} 0 & 3 \\ 3 & 0 \end{bmatrix} \begin{bmatrix} 1 & 2 \\ 2 & 1 \end{bmatrix}$$

$$1^2 + 1^2 + 1^2 + 1^2 = 4$$

2. **Alice is trying to extract the texture from the following two pictures. Meaning** 1 point

2. **Alice is trying to extract the texture from the following two pictures. Meaning she is trying to create an image with no gold coins or chocolate bears, but rather the texture of gold and chocolate. She is trying to generate the images on the right from the images on the left.** 1 point



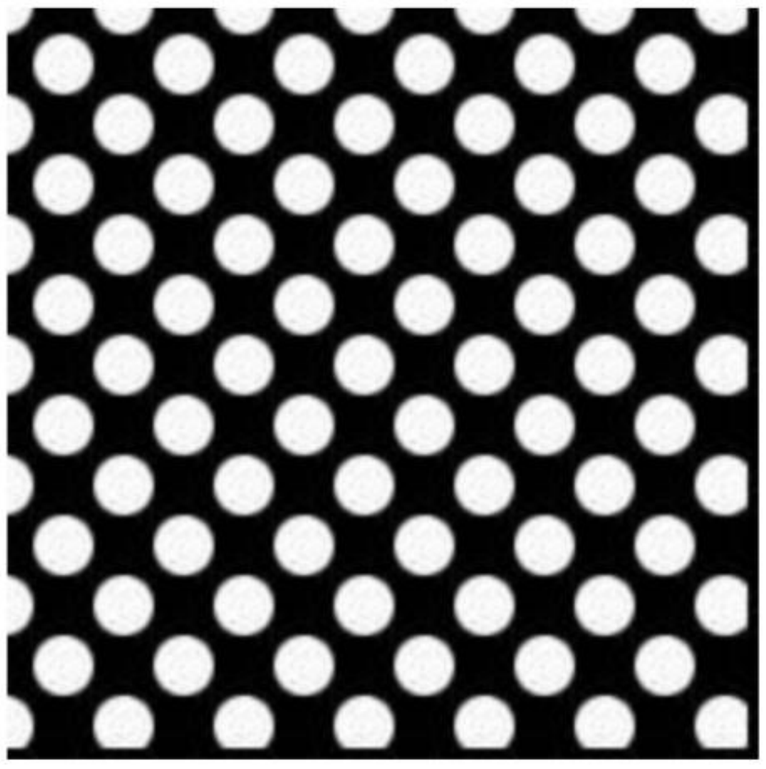
see explanation below

- ○ Quilt_random with small patch, low tolerance
- ◉ Quilt_simple with small patch, high tolerance → see the images... clearly small patches were used because textures were pretty much preserved, but the patches were not large enough to capture gold coins or candy bars
- ○ Quilt_cut with large patch, low tolerance
- ○ Quilt_cut with small patch, low tolerance
- ○ All of the above

3. **Order the following synthesized textures by increasing patch size.** 1 point

1.

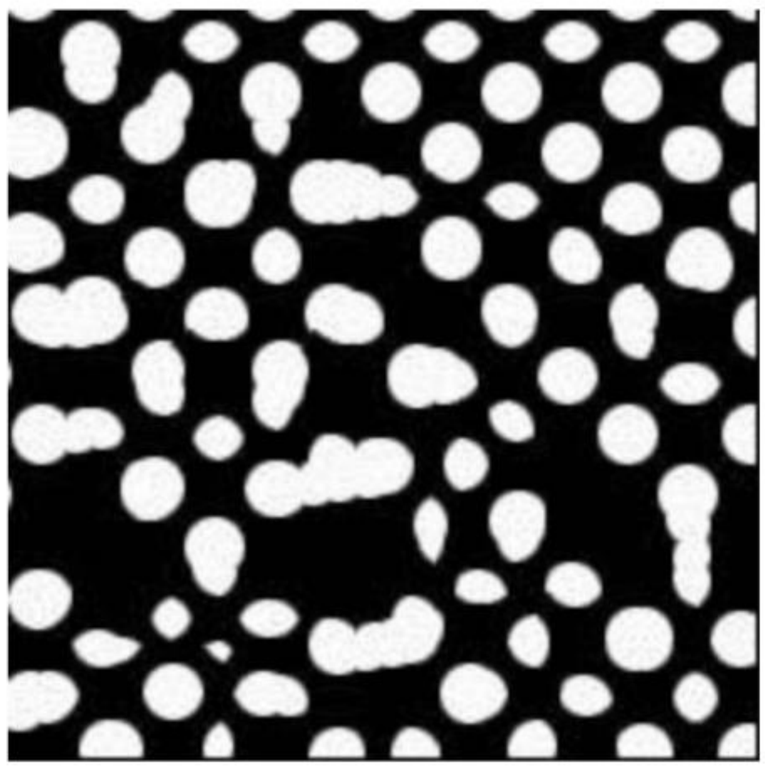
2.



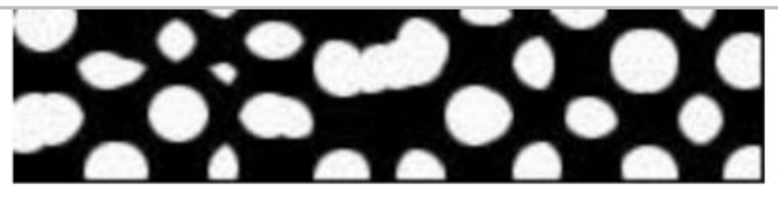
3 1 4 2

3.

4.



3. 

4. 

- 1,2,3,4
- 3,1,2,4
- 2,4,1,3
- 3,1,4,2 ← just see which pattern is preserved the best. This relates to patch size (for this texture)
- None of the above

4. When performing texture transfer, which of the following is False? 1 point

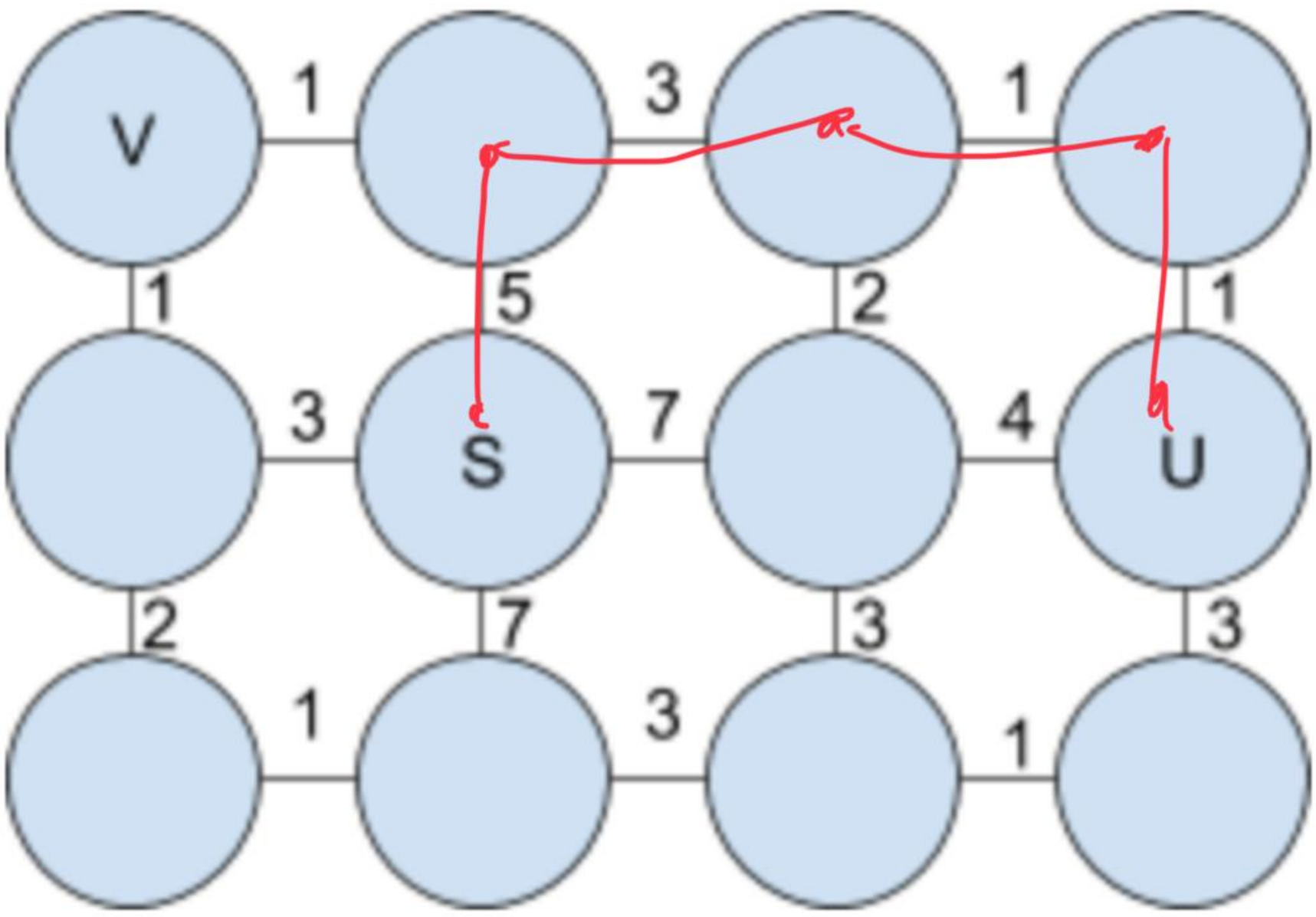
- Your source texture should have a wide range of intensities for good depth of intensity in the target.
- The cost image for texture transfer can be computed as

$$SSD_{transfer} - \alpha\left(SSD_{transfer} - SSD_{overlap}\right)$$

for some choice of α.

- To choose candidate patches, you randomly sample K patches from the source image and then pick the one that has minimum cost within a tolerance.
- Both B and C
- None of the above

1. **In the following graph what is the shortest path from S to U?** 1 point



just know we can use Djikstra's to do this

- 10
- 11
- 6
- 14
- None of the above

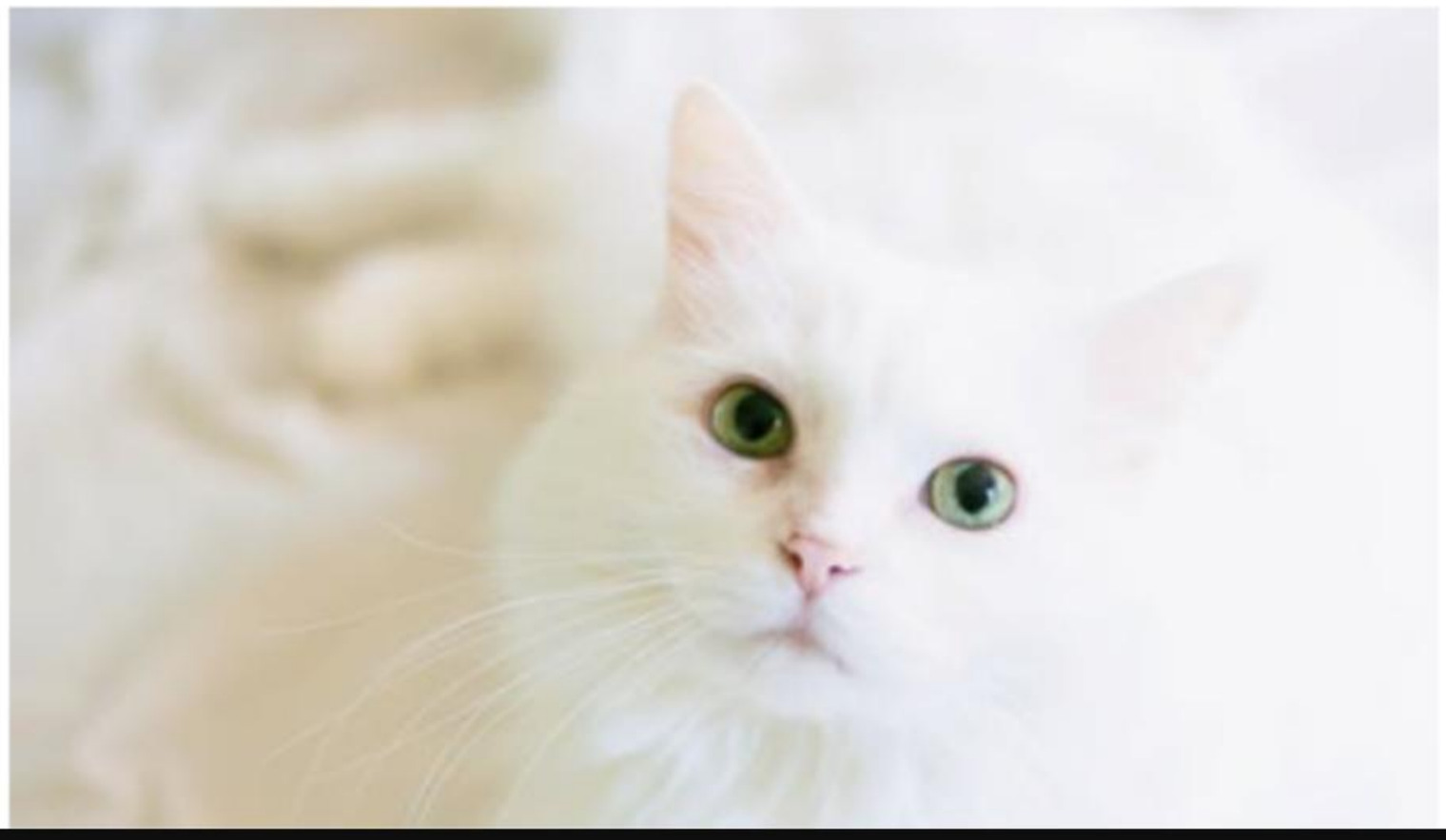
2. **In which of the following pictures will it be easiest to segment out the cat with** 1 point

2. **In which of the following pictures will it be easiest to segment out the cat with intelligent scissors?** 1 point

○

- lack of distinction between the cat and the floor

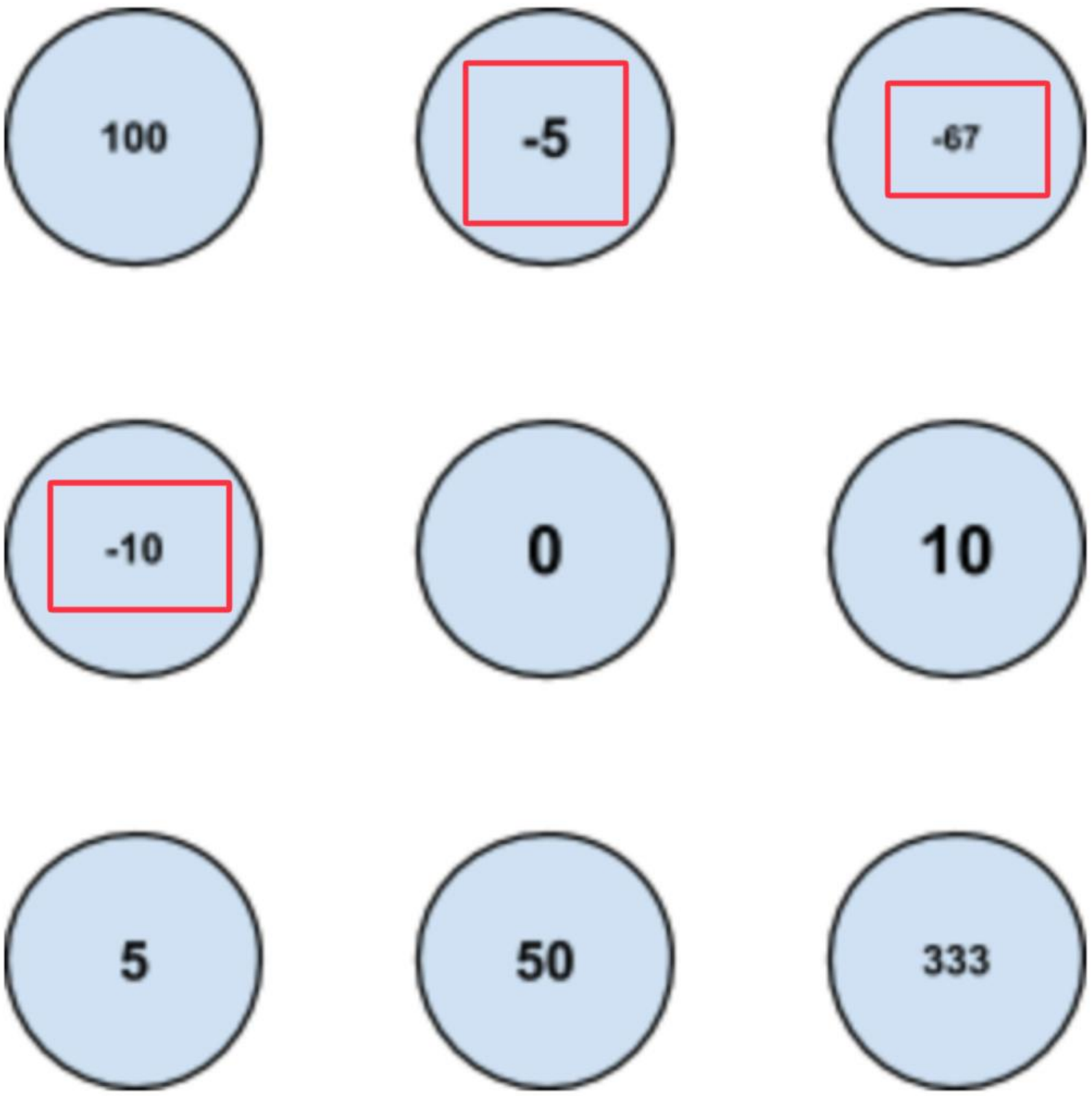
○



Same with this image

These two have better contrast, but the image on the top has more hair, thus making a distinction between the floor and the cat a bit harder

3. **Suppose you are using unary potential to assign weights to a pixel in the following image graph. The unary potential is the value in the nodes. How many nodes will have a bias to be assigned to the foreground ?** 1 point



Energy is minimized, so negative values mean a bias to the foreground

- 6
- 5

- 6
- 5
- 3
- 4
- None of the above

correct answer: Seam Carving

4. **True or False? When performing image stitching, you find the minimum cost path through the image of gradient magnitudes, and remove the pixels along this path.** 1 point

- True
- False

5. **Could you encourage the choice of certain edges in the intelligent scissors algorithm by assigning negative edge weights to them?** 1 point

- Yes
- No
- It depends

"Djikstra's fails with negative edge weight Cycle"

6. **In which of the following cases would it be most difficult to segment out the person with GrabCut (Graph cut based segmentation)?** 1 point

-

6. **In which of the following cases would it be most difficult to segment out the person with GrabCut (Graph cut based segmentation)?** 1 point

clear distinction between person and background

"Low contrast with focus on color rather than fine structure"

← Back

Quiz 5.1

Practice Assignment • 10 min

English

1. Which of these best describes the key idea of pyramid blending? 1 point

- At low frequencies, blend slowly; At high frequencies, blend slowly
- [x] At low frequencies, blend slowly; At high frequencies, blend quickly
- At low frequencies, blend quickly; At high frequencies, blend slowly
- At low frequencies, blend quickly; At high frequencies, blend quickly

→ this will result in overall colors to blend slowly into each other, but details in textures to blend quickly.

2. Which of the following statements is false? 1 point

- [x] Poisson blending preserves gradient of the source region without changing the background
- [x] Pixels are pretty blocky if you use cut and paste
- [x] Foreground colors stay the same when we do poisson blending
- [x] One should feather when doing alpha compositing

→ this is something we lose in Poisson blending. The result is invariant to overall color, only caring about difference in color

3. Given the source, background, and target images as below. 1 point

source image

1 20	5 20	9 20	13 20
2 20	6 80	10 20	14 20
3 20	7 20	11 80	15 20
4 20	8 20	12 20	16 20

background image

1 10	5 10	9 10	13 10
2 10	6 10	10 10	14 10
3 10	7 10	11 10	15 10
4 10	8 10	12 10	16 10

target image

1 10	5 10	9 10	13 10
2 10	6 v_1	10 v_3	14 10
3 10	7 v_2	11 v_4	15 10
4 10	8 10	12 10	16 10

What are (a, b, c, d, e, f, g, h) in the following equation?

← Back

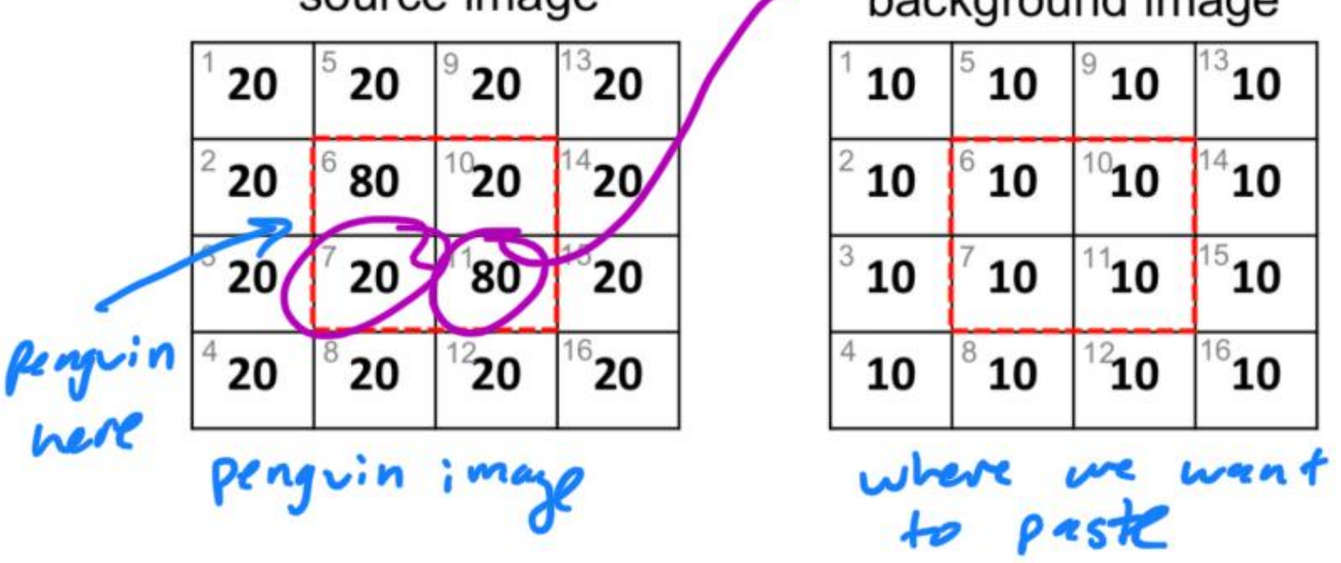
Quiz 5.1

Practice Assignment • 10 min

English

$v_4 - v_2 \simeq s_{11} - s_7$ ... so we need [0 -1 0 1] to get v_4 and $-v_2$

3. **Given the source, background, and target images as below.** (gradient domain editing) 1 point



What are (a, b, c, d, e, f, g, h) in the following equation?

$$\begin{bmatrix} a & b & c & d \\ e & f & g & h \\ & \vdots & \vdots & \end{bmatrix} \begin{bmatrix} v_1 \\ v_2 \\ v_3 \\ v_4 \end{bmatrix} = \begin{bmatrix} S_{11} - S_7 \\ S_7 - S_3 + t_3 \\ \vdots \end{bmatrix}$$

A: pixels we are solving for; C; # of rows will be # of constraints between pixels; get coefficients on one side and constants on other... already done.

$$V = \underset{v}{\operatorname{argmin}} \sum ((v_i - v_j) - (s_i - s_j))^2 + \sum ((v_i - t_j) - (s_i - s_j))^2$$

$\underline{V_2}$ so $[0\ 1\ 0\ 0]$

- ○ (-1, 0, 1, 0, 0, 1, 0, 1)
- ◉ (0, -1, 0, 1, 0, 1, 0, 0)
- ○ (0, 1, 0, -1, 0, 1, 0, 0)
- ○ (0, 1, 0, 1, 0, -1, 0, 0)

2 constraints

1. The difference between neighboring pixels in the source image should be equal to the difference we get in the target image
2. Neighboring pixels for which one pixel is in the target region (where the penguin goes), the difference between those pixels should be maintained from source to target image

4. **In mixed gradient, we have the following equation:** 1 point

$$\begin{bmatrix} e & f & g & h \\ \vdots & \vdots & & \end{bmatrix} \begin{bmatrix} v_2 \\ v_3 \\ v_4 \end{bmatrix} = \begin{bmatrix} S_7 - S_3 + t_3 \\ \vdots \end{bmatrix}$$

- (-1, 0, 1, 0, 0, 1, 0, 1)
- (0, -1, 0, 1, 0, 1, 0, 0)
- (0, 1, 0, -1, 0, 1, 0, 0)
- (0, 1, 0, 1, 0, -1, 0, 0)

4. **In mixed gradient, we have the following equation:** 1 point

$$\mathbf{v} = \underset{\mathbf{v}}{\operatorname{argmin}} \sum_{i \in S, j \in N_i \cap S} ((v_i - v_j) - d_{ij})^2 + \sum_{i \in S, j \in N_i \cap \neg S} ((v_i - t_j) - d_{ij})^2$$

where d_{ij} is the gradient from source or target with larger magnitude. Suppose the gradient of source image is -10 and the gradient of the target image is 2: what is d_{ij}?

- -10
- 10
- 2
- -2

-10 < 2

← Back

Quiz 5.2

Practice Assignment • 10 min

English

1. **Suppose there is a point (x, y), and we rotate clockwise to (x', y'). What are (a, b, c, d)?** 1 point

$$\begin{bmatrix} x' \\ y' \end{bmatrix} = \begin{bmatrix} a & b \\ c & d \end{bmatrix} \begin{bmatrix} x \\ y \end{bmatrix}$$

what is the linear transformation $\begin{bmatrix} a & b \\ c & d \end{bmatrix}$ that will take $\begin{bmatrix} x \\ y \end{bmatrix}$ to $\begin{bmatrix} x' \\ y' \end{bmatrix}$?

- ○ $(\cos\theta, -\sin\theta, \sin\theta, \cos\theta)$
- ○ $(\cos\theta, \sin\theta, \sin\theta, \cos\theta)$
- ◉ $(\cos\theta, \sin\theta, -\sin\theta, \cos\theta)$ (a b c d)
- ○ $(\cos\theta, \sin\theta, \sin\theta, -\cos\theta)$

from lectures:

$x' = x\cos(\theta) - y\sin(\theta)$

$y' = x\sin(\theta) + y\cos(\theta)$

so ...

$$\begin{bmatrix} \cos\theta & \sin\theta \\ -\sin\theta & \cos\theta \end{bmatrix} \begin{bmatrix} x \\ y \end{bmatrix}$$

this is for counter clockwise, so switch x and y for clockwise

2. **What transformation cannot be represented by a 2x2 matrix?** 1 point

- ○ 2D rotation around (0, 0)

← Back

Quiz 5.2

Practice Assignment • 10 min

English

2. What transformation cannot be represented by a 2x2 matrix? 1 point

- 2D rotation around (0, 0)
- 2D shear
- 2D scale
- 2D translation

homogenous coordinates

$\begin{bmatrix} x \\ y \end{bmatrix} \rightarrow \begin{bmatrix} x \\ y \\ 1 \end{bmatrix}$

point to ray

translation $= \begin{bmatrix} 1 & 0 & t_x \\ 0 & 1 & t_y \\ 0 & 0 & 1 \end{bmatrix}$

3. Which homogeneous coordinate is different from others? 1 point

- (9, 6, 3)
- (12, 8, 4)
- (48, 32, 16)
- (4, 2, 1)

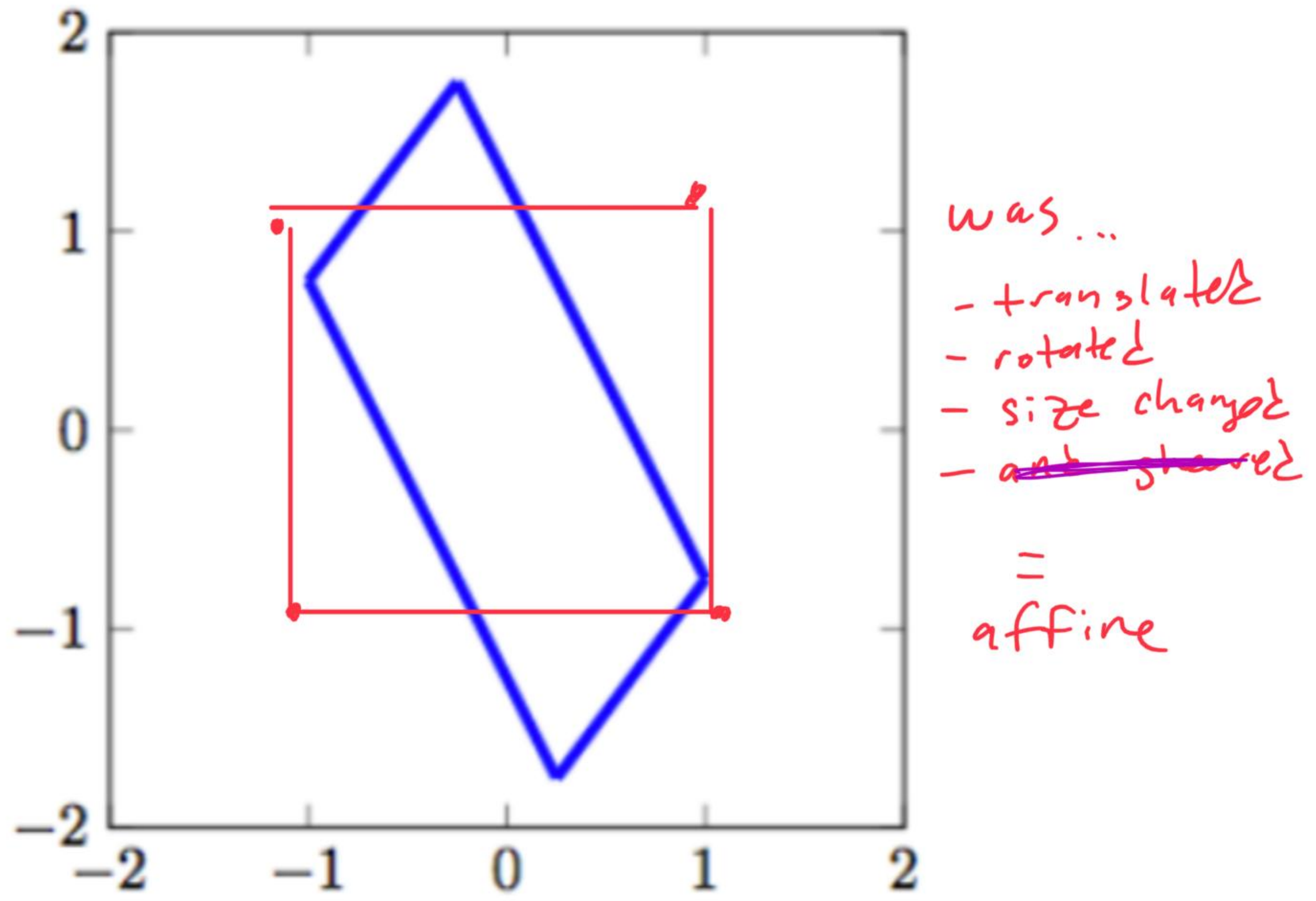
ratio between each value is constant

4. What properties do affine transformations and projective transformations have in common? 1 point

- Parallel lines remain parallel under projection
- Origin does not necessarily map to origin
- Ratios are preserved

5. For projective transformation, what is the degrees of freedom? And what is the minimum number of 2D point correspondences required to solve the transformation? 1 point

6. **The figure is the output of applying one of the transformations below to a square with vertices (-1, 1), (-1, -1), (1, 1), (1, -1). Which transformation is it (pick most restrictive possible)?** 1 point



- Affine (preserves lines and parallelism,)
- Rigid
- Projective
- Similarity

← Back

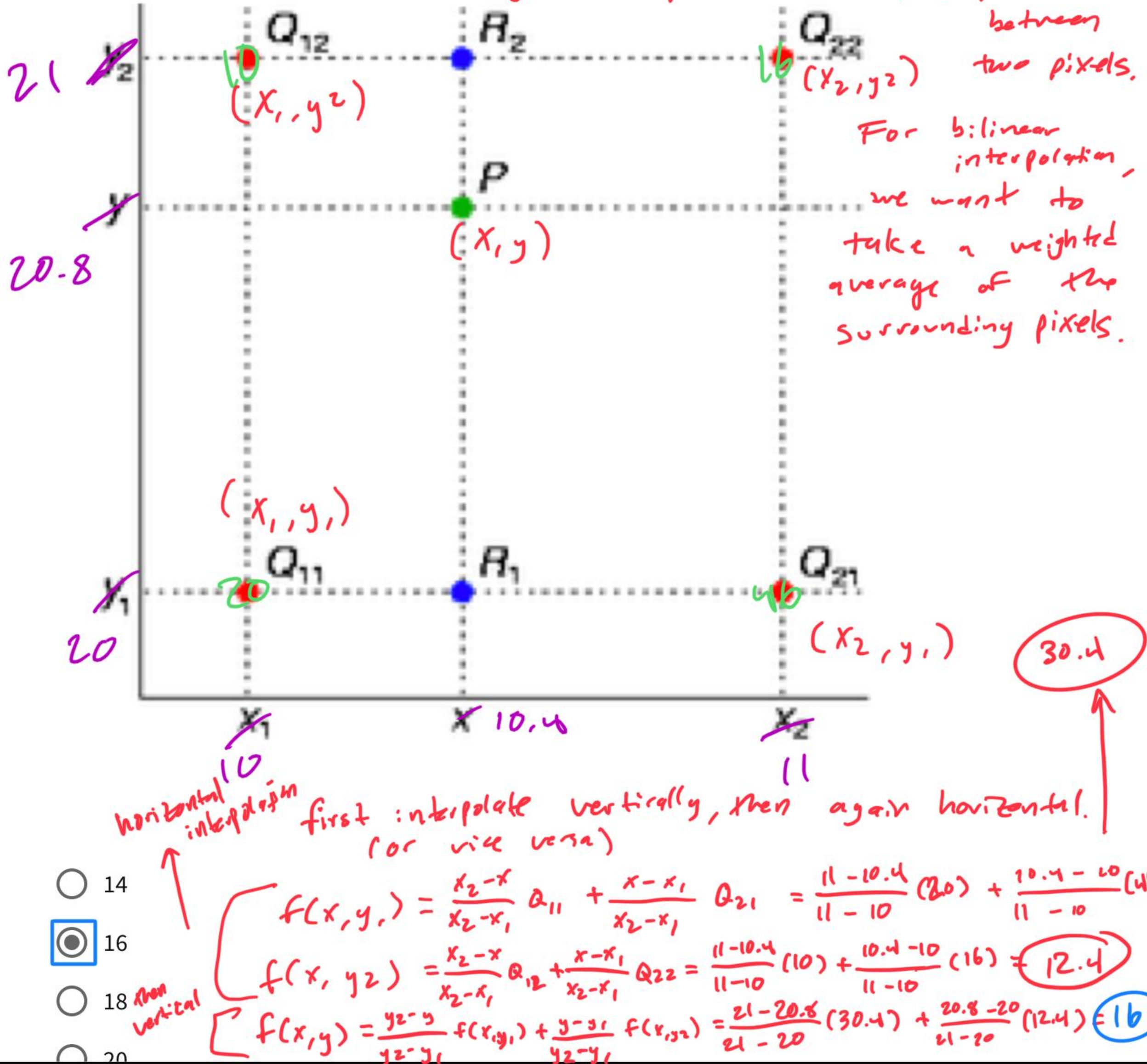
Quiz 6.1

Practice Assignment • 10 min

English

1. **In the following figure, let (x1, y1) = (10, 20), (x2, y2) = (11, 21), and (x, y) = (10.4, 20.8). Also Q_{11} = 20, Q_{12} = 10, Q_{21} = 46, Q_{22} = 16. What is P when we apply bilinear interpolation** 1 point

we are basically asking what value should be given to P in a mapping, as P falls between two pixels.



For bilinear interpolation, we want to take a weighted average of the surrounding pixels.

horizontal interpolation first: interpolate vertically, then again horizontal. (or vice versa)

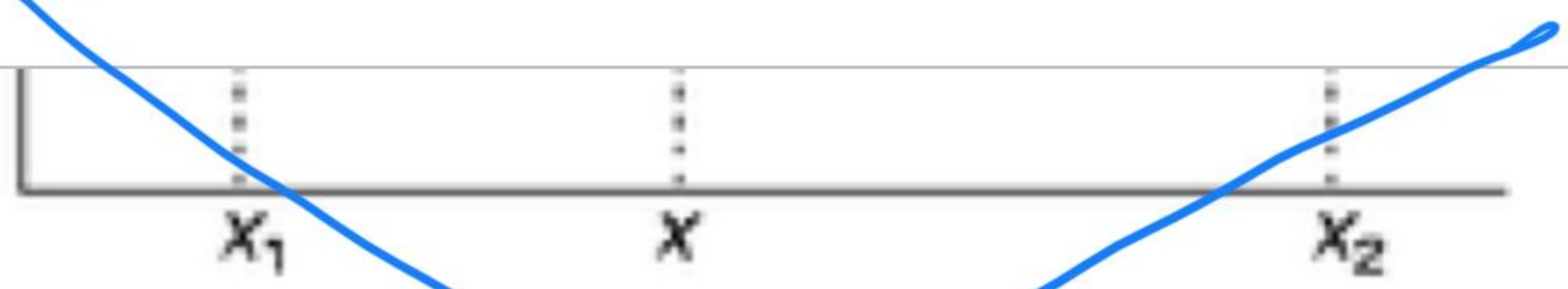
$$f(x, y_1) = \frac{x_2 - x}{x_2 - x_1} Q_{11} + \frac{x - x_1}{x_2 - x_1} Q_{21} = \frac{11 - 10.4}{11 - 10}(20) + \frac{10.4 - 10}{11 - 10}(46)$$

$$f(x, y_2) = \frac{x_2 - x}{x_2 - x_1} Q_{12} + \frac{x - x_1}{x_2 - x_1} Q_{22} = \frac{11 - 10.4}{11 - 10}(10) + \frac{10.4 - 10}{11 - 10}(16) = 12.4$$

then vertical

$$f(x, y) = \frac{y_2 - y}{y_2 - y_1} f(x, y_1) + \frac{y - y_1}{y_2 - y_1} f(x, y_2) = \frac{21 - 20.8}{21 - 20}(30.4) + \frac{20.8 - 20}{21 - 20}(12.4) = 16$$

- 14
- 16
- 18
- 20



- 14
- 16
- 18
- 20

2. **Which of these best describes morphing?** 1 point

- An average of two images of objects
- An image of the average object

1. determine corresponding points
2. define triangulation
3. compute average shape
4. warp both images towards the average shape
5. cross dissolve

3. **Put these operations in the correct order to perform morphing: (op1) determine corresponding points; (op2) compute average shape; (op3) define triangulation; (op4) warp both images toward the average shape; (op5) cross dissolve.** 1 point

- (op2) -> (op1) -> (op3) -> (op4) -> (op5)
- (op1) -> (op2) -> (op4) -> (op3) -> (op5)
- (op1) -> (op3) -> (op2) -> (op4) -> (op5)
- (op3) -> (op1) -> (op2) -> (op4) -> (op5)

from lectures:

"Summary of morphing"

1. Define corresponding points
2. Define triangulation of points
3. for each step:
   - get the affine projection to the corresponding triangles in each image
   - for each pixel in each triangle, find corresponding points and set value to weighted average
4. Save image as next frame of the sequence

← Back

Quiz 6.2

Practice Assignment • 10 min

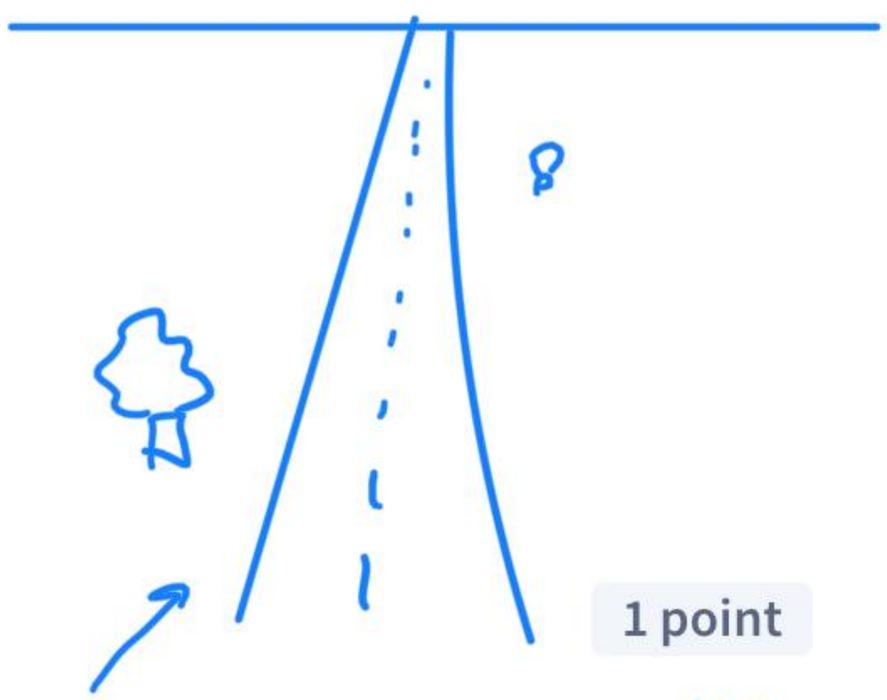
English

1. What is not lost in projective geometry? 1 point

- Length
- Aangle
- Straightness of line

unlike the other two options, a straight line in the world will always be projected straight in the camera

2. Which of the following is False? 1 point



- In projective geometry, all lines that intersect in the image are parallel in 3D

So while parallel lines in the image could imply parallel in 3D, this is not always true. Just because the lines look like they intersect at a common vanishing point does not mean they are actually parallel.

- The projection of parallel 3D lines intersect at a point
  - ↳ if the lines are parallel in 3D, the lines WILL intersect
- Vanishing line corresponds to the 3D orientation of a surface
  - ↳ the vanishing line (horizon) of a ground plane = horizon
- In homogeneous coordinates, the intersection of two lines can be computed as the cross product of the line parameters
  - ↳ homo. coordinates = line = $(a, b, c) \rightarrow ax + by + c = 0$
  - ↳ intersection of two lines = $L_1 \times L_2$
  - ↳ why does this work? The cross product will yield a point that satisfies both line equations, making it the point of intersection

3. How many Degree of freedom (DoF) for a general intrinsic matrix? And for extrinsic matrix? 1 point

- 9, 12
- 5, 6
- 4, 9
- 2, 3

variables we need to solve for

$$K = \begin{bmatrix} \frac{1}{\alpha} & \frac{s}{\beta} & \frac{u_0}{v_0} \\ 0 & \frac{\beta}{0} & \frac{v_0}{1} \end{bmatrix} = 5 \text{ DOF}$$

- focal length scaled by pixel size in x dir.
- " " " y dir
- skew
- principal points (center) of image

3x1 translation vector, describing position, 3 DOF, x, y, z.

$$[R \; t]$$

3x3 rotation matrix describing orientation, 3 DOF, for roll, pitch, yaw

= 6 DOF

$P = \begin{bmatrix} X \\ Y \\ Z \\ 1 \end{bmatrix}$

no rotation or translation means

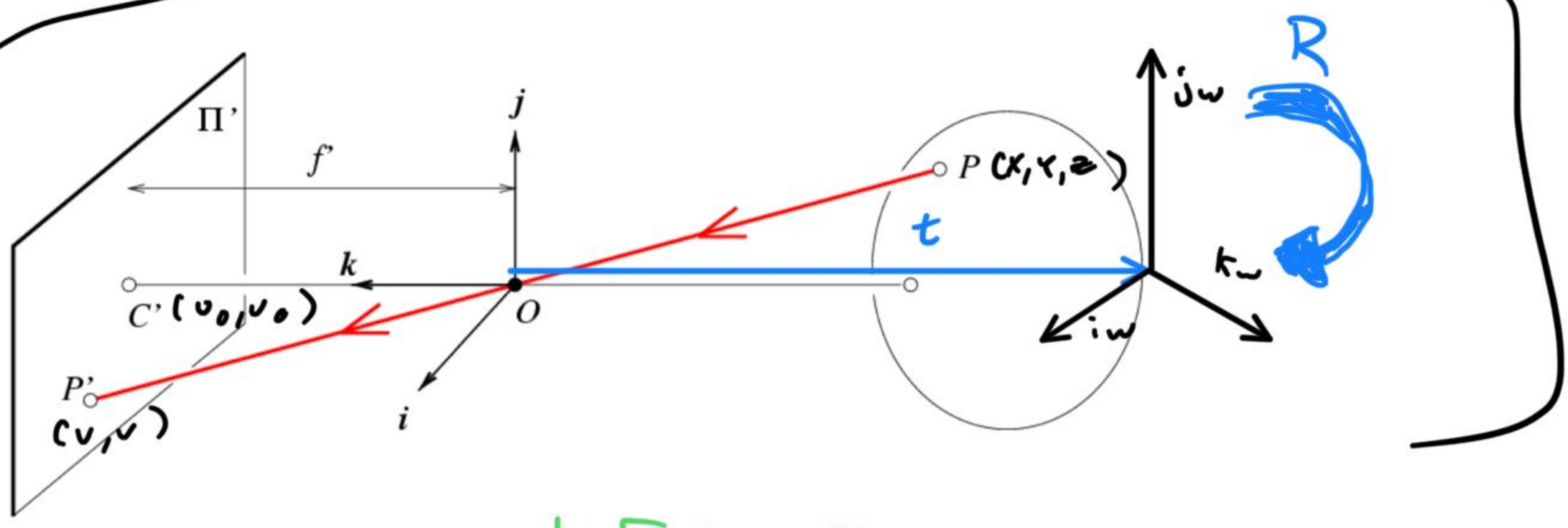
$P_{camera} = P$

$\begin{bmatrix} u' \\ v' \\ w' \end{bmatrix} = K \cdot P = \begin{bmatrix} f & 0 & u_0 & 0 \\ 0 & f & v_0 & 0 \\ 0 & 0 & 1 & 0 \end{bmatrix} \begin{bmatrix} X \\ Y \\ Z \\ 1 \end{bmatrix} = \begin{bmatrix} fX + u_0 Z \\ fY + v_0 Z \\ Z \end{bmatrix}$

~~$fx + 0y + u_0 z + 0$~~
~~$dx + fy$~~

4. Suppose P=(X, Y, Z), P'=(u, v), and C'=(u_0, v_0). Let's also assume that there is no rotation or translation of the camera. What is u? 1 point

PINHOLE MODEL



$x = K[R\ t]X$

- $f\frac{X}{Z} + u_o$
- $Z\frac{X}{f} + u_o$
- $f\frac{Y}{Z} + u_o$

x = image coordinates: (u, v, 1)
K = intrinsic matrix
extrinsic matrix [R = rotation, t = translation
X = world coordinates

So, "what is u?" is just asking for the x coordinate projection on the image plane of P.

why is the answer $f\frac{x}{z} + v_o$?

↳ the formula for mapping a 3D point (X, Y, Z) to a 2D point (u, v) are:

$u = f\frac{x}{z} + u_o$
$v = f\frac{y}{z} + v_o$

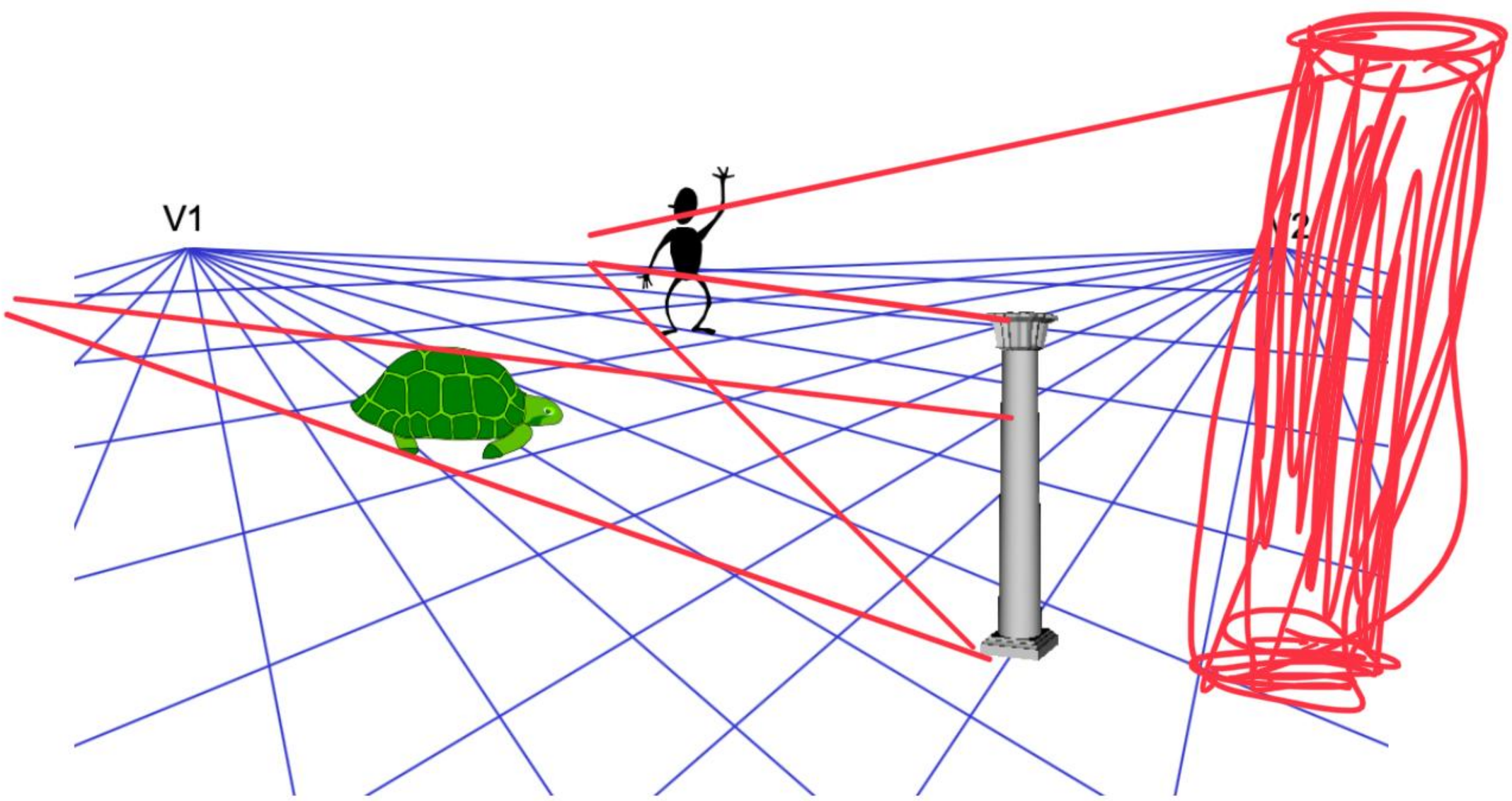
← Back

Quiz 7.1

Practice Assignment • 10 min

English

1. V1 and V2 are two vanishing points on the horizon. Which object below is the tallest one? 1 / 1 point

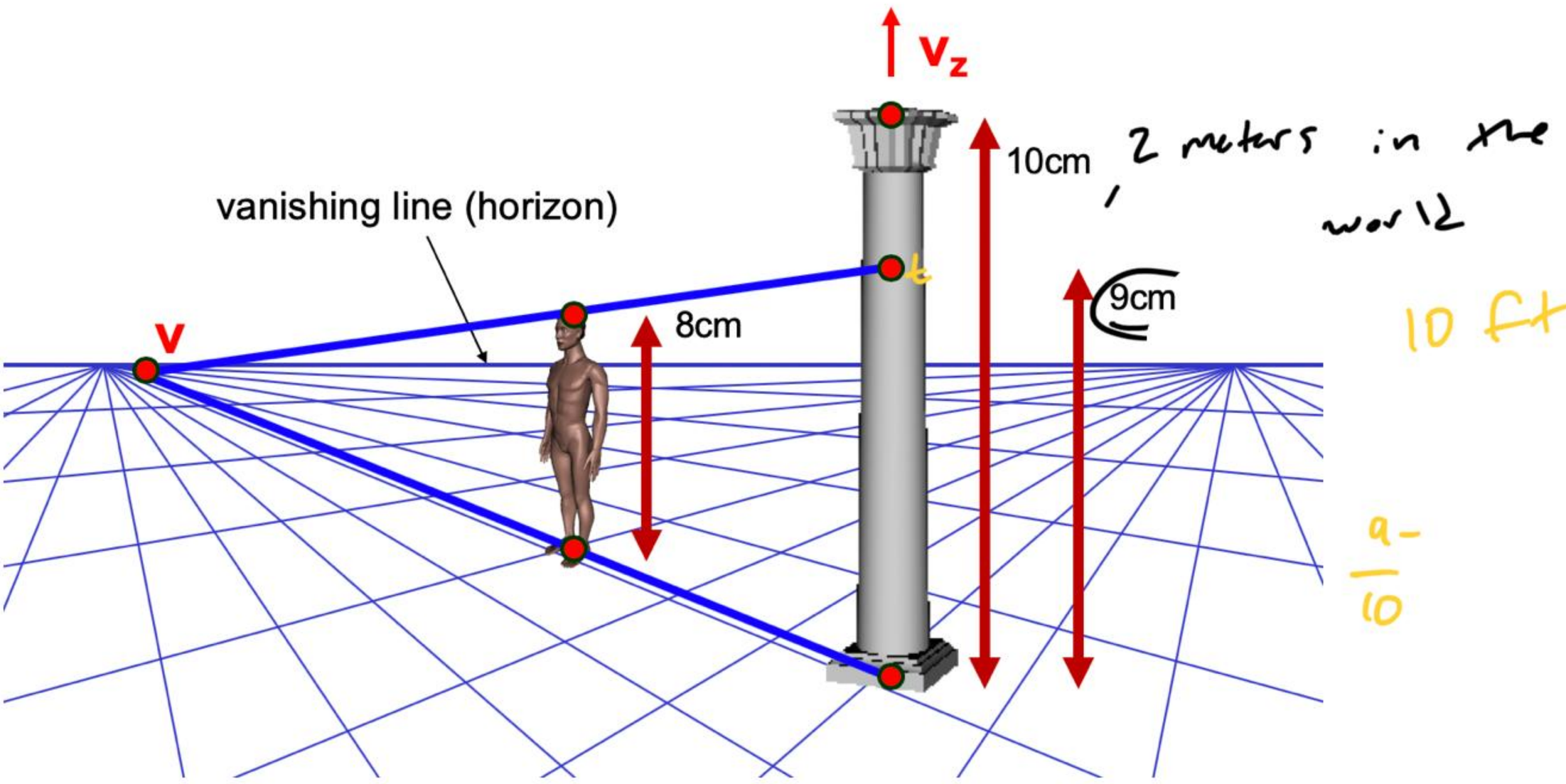


- The camera
- The pillar
- The turtle
- The man

Correct

2. Point V is on the horizon. The pillar is 2 meters tall in 3D space. You measured some objects in the 2D image plane, as shown below. E.g., in the image plane, the pillar is 10/8 times as large as the man. Can you determine the height of the man?

1 / 1 point



- 2 meters
- 1.8 meters
- 1.6 meters
- Insufficient data

we know that the ratio will remain the same in 2D as it is in 3D.

Thus: cross ratio can be used

$$\text{Cross ratio} = \frac{|t-b|\,|v_z-r|}{|r-b|\,|v_z-t|}$$

$$\frac{q-0}{10-0} = \frac{q}{10} \rightarrow \frac{q}{10} \cdot 2 = 1.8$$

3. Which f-number below will make the photo have the most depth of field? 1 / 1 point

- f/5.6
- f/8
- f/32
- All of the above are the same.

larger denominator = larger DOF

- reducing aperture = increasing dof, because only light passing through at shallower angles will get through

Correct

4. What will happen to your photo if you decrease the aperture of your camera? 1 / 1 point

- More depth of field and less light
- More temporal resolution and less light
- Less depth of field and more light
- More depth of field and more light

← Back

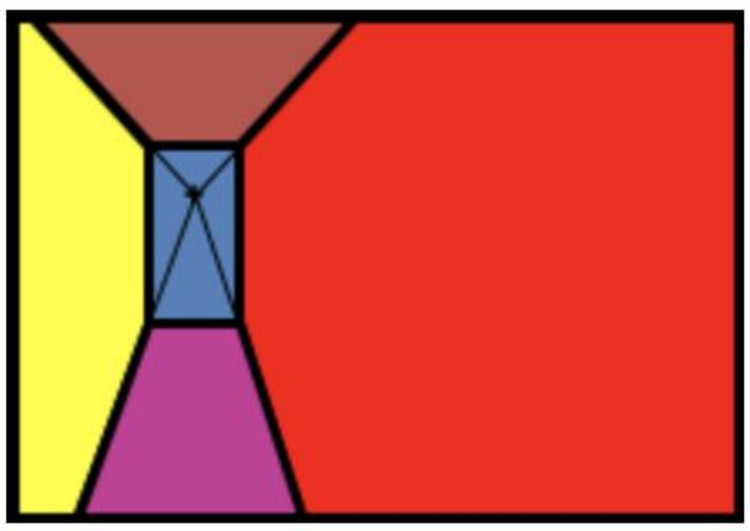
Quiz 7.2

Practice Assignment • 10 min

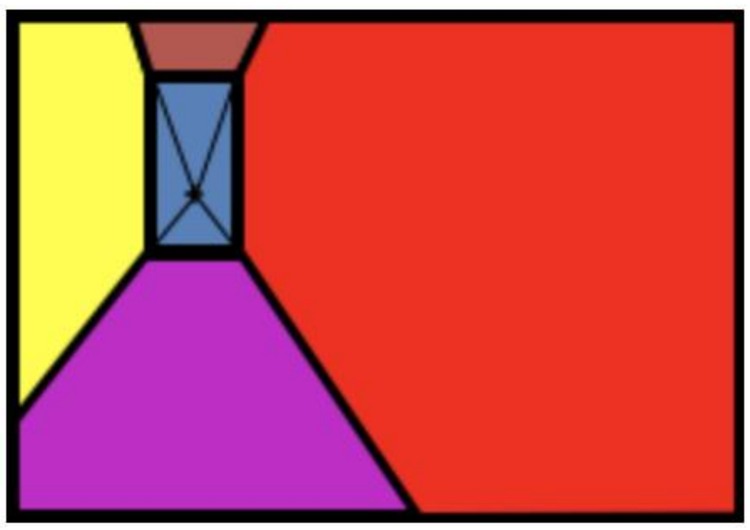
English

1. Assume the camera is looking straight at the back wall (blue part), and the vanishing point is marked in the pictures, which picture is taken by the camera with the lowest position? 1 point

○



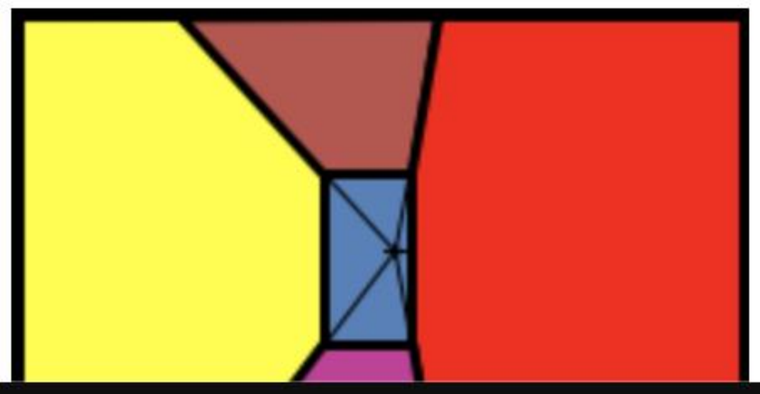
◉



→ you can tell that this looks like it is taken from a hunched over position

The higher the blue rect. in the image, the lower the viewing position.

○



← Back

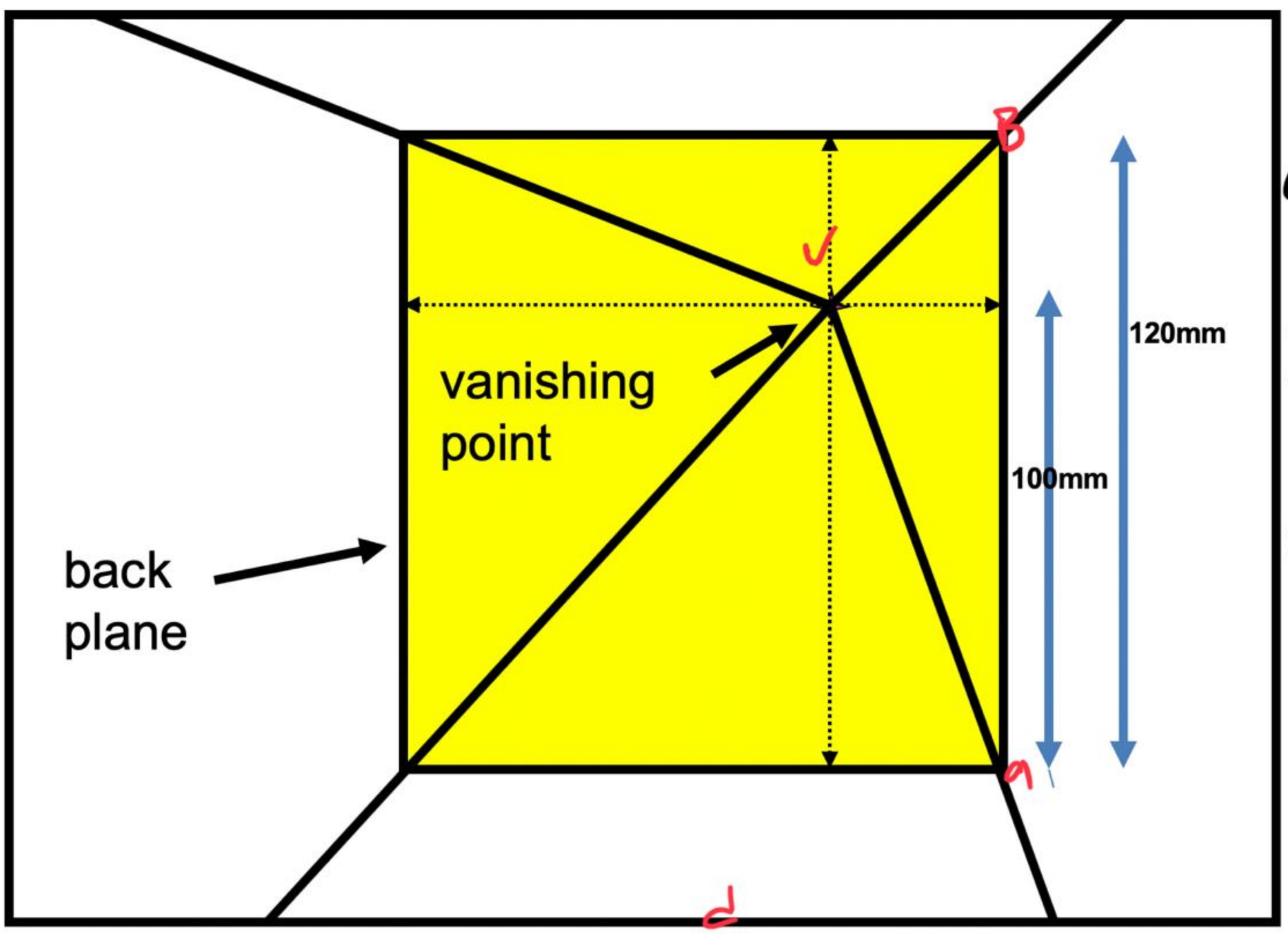
Quiz 7.2

Practice Assignment • 10 min

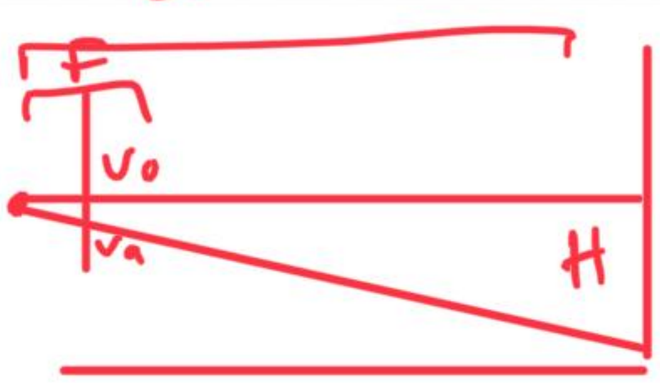
English

2. Suppose you took a picture with a camera placed 1m above the ground with 300mm focal length. You measured the length of some lines in the image below. How far away is the camera from the back plane? (Note that the focal length and image measurements are written in mm units here, but commonly they would be denoted in pixel units)

1 point



Answer: 3 m



$$\frac{f}{v_1 - v_0} = \frac{d}{H}$$

So...

$$\frac{300}{100} = \frac{d}{1 \text{ meter}}$$

d = 3 m

- 2m
- 2.5m

3. You are trying to compute the homography to unwarp an image. Suppose you get point **p**' for the target position and **p** from the original image, and you setup homography matrix **H**, what equations can you derive? 1 point

Explanation: our goal here is to transform $p' = Hp$ into a system of equations we can solve for. This process is just matrix simplification. First, get the system of equations where we can solve for w'. Then, substitute w' into the equations for $w'u'$ and $w'v'$. Doing this, we can set the equations to 0 and solve to get a different form.

linear transformation

$$\mathbf{p}' = \mathbf{H}\mathbf{p} \qquad \mathbf{p}' = \begin{bmatrix} w'u' \\ w'v' \\ w' \end{bmatrix} \quad \mathbf{p} = \begin{bmatrix} u \\ v \\ 1 \end{bmatrix} \quad \mathbf{H} = \begin{bmatrix} h_1 & h_2 & h_3 \\ h_4 & h_5 & h_6 \\ h_7 & h_8 & h_9 \end{bmatrix}$$

$$w'u' = h_1u + h_2v + h_3$$
$$w'v' = h_4u + h_5v + h_6$$
$$w' = h_7u + h_8v + h_9$$

$$h = \begin{bmatrix} h_1 \\ h_2 \\ h_3 \\ \dots \\ h_9 \end{bmatrix}$$

$$\mathbf{h} = [h_1, h_2, h_3, h_4, h_6, h_7, h_8, h_9]^T$$

↳ key idea: convert $p' = Hp$ into the equivalent

Substitute:

$$(h_7u + h_8v + h_9)u' = h_1u + h_2v + h_3$$
$$\hookrightarrow h_7uu' + h_8vu' + h_9u' = h_1u + h_2v + h_3$$
$$h_7uv' + h_8vv' + h_9v' = h_4u + h_5v + h_6$$

doing the same for eq. 2 gives

Now we need to rearrange both to get like terms on each side

$$\textcircled{1}\ h_7uu' + h_8vu' + h_9u' - h_1u - h_2v - h_3 = 0$$

$$\textcircled{2}\ h_7uv' + h_8vv' + h_9v' - h_4u - h_5v - h_6 = 0$$

○
$$\begin{bmatrix} -u & -v & -1 & 0 & 0 & 0 & uu' & vu' & u' \\ -u & -v & -1 & 0 & 0 & 0 & uv' & vv' & v' \end{bmatrix} \mathbf{h} = \mathbf{0}$$

○
$$\begin{bmatrix} -u & -v & -1 & 0 & 0 & 0 & uu' & vu' & u' \\ 0 & 0 & 0 & -u & -v & -1 & uv' & vv' & v' \end{bmatrix} \mathbf{h} = \mathbf{0}$$

○
$$\begin{bmatrix} 0 & 0 & 0 & -u & -v & -1 & uu' & vu' & u' \\ -u & -v & -1 & 0 & 0 & 0 & uv' & vv' & v' \end{bmatrix} \mathbf{h} = \mathbf{0}$$