# **EXAMPLE** Exam in
# 02504 Computer Vision
*Spring 2023*

## General information

- The exam consists of 20-30 questions. All questions have equal weight: the correct answer gives 1 point, incorrect or missing answer gives 0 points. You only need to submit the answers to the questions. You should not upload any notes or calculations.
- There is *one* correct answer for each question. Some of the numeric results have been rounded, and may deviate slightly from your result. This should not prevent you from being able to pick the correct answer.
- Each page contains one question. If there are illustrations and images, those refer to the question on that page.
- The notation in the questions is the same as used in the course slides.
- You can load files for a specific exercise using
  - `np.load("filename.npy", allow_pickle=True).item()`

## Relevant links

Resources are available for a subset of questions in form of data, images, and code. Filenames typeset in `typewriter font` indicate that you can find files in the `materials` folder.

# Question 1

A camera has focal length 800, principal point (900, 580), $\alpha = 1$, $\beta = 0$, and radial distortion parameters $k_3 = 0.03$ and $k_5 = 0.04$.

What is the camera matrix?

a) $\begin{bmatrix} 800 & 0 & 900 \\ 0 & 824 & 580 \\ 0 & 0 & 1 \end{bmatrix}$

b) $\begin{bmatrix} 800 & 24 & 900 \\ 0 & 800 & 580 \\ 0 & 0 & 1 \end{bmatrix}$

c) $\begin{bmatrix} 800 & 0 & 900 \\ 0 & 800 & 580 \\ 0 & 0 & 1 \end{bmatrix}$

d) $\begin{bmatrix} 800 & 32 & 900 \\ 0 & 800 & 580 \\ 0 & 0 & 0 \end{bmatrix}$

e) $\begin{bmatrix} 800 & 0 & 900 \\ 0 & 800 & 580 \\ 0 & 0 & 0 \end{bmatrix}$

f) $\begin{bmatrix} 800 & 0 & 900 \\ 0 & 800 & 580 \\ 0 & 0 & 800 \end{bmatrix}$

g) $\begin{bmatrix} 800 & 0 & 900 \\ 0 & 832 & 580 \\ 0 & 0 & 1 \end{bmatrix}$

# Question 2

How many degrees of freedom does a homography matrix have?

a) 1

b) 2

c) 3

d) 4

e) 5

f) 6

g) 7

h) 8

i) 9

j) 10

k) 11

l) 12

# Question 3

A camera has focal length 350 and principal point $(700, 390.0)$. The camera has the rotation:

```
cv2.Rodrigues(np.array([0.1, -0.2, -0.1]))[0]
```

and the translation:

```
np.array([[0.03], [0.06], [-0.02]])
```

A 3D point in the world coordinate system has coordinates:

```
np.array([0.35, 0.17, 1.01])
```

What is the projection of this point to the camera's image plane?

a) $[760.42, 423.38]^{\mathrm{T}}$

b) $[761.88, 424.48]^{\mathrm{T}}$

c) $[823.26, 449.34]^{\mathrm{T}}$

d) $[829.50, 453.40]^{\mathrm{T}}$

e) $[821.29, 448.91]^{\mathrm{T}}$

f) $[799.17, 444.95]^{\mathrm{T}}$

g) $[821.33, 449.80]^{\mathrm{T}}$

# Question 4

Harris corner detector. For a small region of the image, we have computed the elements of the smoothed Hessian matrix/structure tensor. They are available in `harris.npy` and also presented here:

$g * (I_x^2)$

| | 0 | 1 | 2 | 3 | 4 |
|---|---|---|---|---|---|
| 0 | 4.2 | 4.7 | 5.2 | 5.4 | 5.4 |
| 1 | 4.8 | 5.5 | 6.1 | 6.5 | 6.5 |
| 2 | 5.4 | 6.2 | 6.9 | 7.4 | 7.4 |
| 3 | 5.8 | 6.7 | 7.6 | 8.1 | 8.1 |
| 4 | 6.0 | 6.9 | 7.8 | 8.3 | 8.3 |

$g * (I_y^2)$

| | 0 | 1 | 2 | 3 | 4 |
|---|---|---|---|---|---|
| 0 | 7.6 | 8.2 | 8.5 | 8.3 | 7.7 |
| 1 | 6.4 | 7.0 | 7.2 | 7.0 | 6.5 |
| 2 | 5.4 | 5.8 | 5.9 | 5.8 | 5.5 |
| 3 | 4.4 | 4.8 | 4.9 | 4.9 | 4.7 |
| 4 | 3.8 | 4.0 | 4.2 | 4.2 | 4.2 |

$g * (I_x I_y)$

| | 0 | 1 | 2 | 3 | 4 |
|---|---|---|---|---|---|
| 0 | -1.9 | -2.3 | -2.4 | -2.3 | -1.9 |
| 1 | -1.1 | -1.4 | -1.6 | -1.5 | -1.3 |
| 2 | -0.3 | -0.5 | -0.7 | -0.7 | -0.6 |
| 3 | 0.4 | 0.3 | 0.2 | 0.2 | 0.2 |
| 4 | 1.0 | 1.0 | 1.0 | 0.9 | 0.8 |

Let $k = 0.06$. Does the Harris corner detector find any corners in the image? Corners are specified as (row index, column index).

a) There is a corner at (2, 2).

b) There is a corner at (2, 3).

c) There is a corner at (2, 1).

d) There is a corner at (1, 2).

e) There is a corner at (3, 1).

f) There is a corner at (1, 1).

g) There is a corner at (3, 2).

h) There is a corner at (1, 3).

i) There is a corner at (3, 3).

j) There is no corner in the image.