



Multiple View Geometry: Exercise Sheet 1

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Part I: Theory

The following exercises have to be **solved at home**. You will present your answers during the tutorials.

1. Show for each of the following sets (1) whether they are linearly independent, (2) whether they span \mathbb{R}^3 and (3) whether they form a basis of \mathbb{R}^3 :

$$(a) B_1 = \left\{ \begin{pmatrix} 1 \\ 1 \\ 1 \end{pmatrix}, \begin{pmatrix} 0 \\ 1 \\ 1 \end{pmatrix}, \begin{pmatrix} 0 \\ 0 \\ 1 \end{pmatrix} \right\}$$

$$(b) B_2 = \left\{ \begin{pmatrix} 2 \\ 1 \\ 0 \end{pmatrix}, \begin{pmatrix} 1 \\ 1 \\ 0 \end{pmatrix} \right\}$$

$$(c) B_3 = \left\{ \begin{pmatrix} 2 \\ 1 \\ 0 \end{pmatrix}, \begin{pmatrix} 3 \\ 1 \\ 0 \end{pmatrix}, \begin{pmatrix} 0 \\ 0 \\ 1 \end{pmatrix}, \begin{pmatrix} 1 \\ 0 \\ 1 \end{pmatrix} \right\}$$

2. Which of the following sets forms a group (with matrix-multiplication)? Prove or disprove!

$$(a) G_1 := \{A \in \mathbb{R}^{n \times n} \mid \det(A) \neq 0 \wedge A^\top = A\}$$

$$(b) G_2 := \{A \in \mathbb{R}^{n \times n} \mid \det(A) = -1\}$$

$$(c) G_3 := \{A \in \mathbb{R}^{n \times n} \mid \det(A) > 0\}$$

3. Prove or disprove: There exist vectors $\mathbf{v}_1, \dots, \mathbf{v}_5 \in \mathbb{R}^3 \setminus \{\mathbf{0}\}$, which are pairwise orthogonal, i.e.

$$\forall i, j = 1, \dots, 5 : \quad \langle \mathbf{v}_i, \mathbf{v}_j \rangle = 0$$

Part II: Practical Exercises

1. Basic image processing

- (a) Download `lena.png`, provided in `ex1.zip`.
- (b) Load the image into the workspace.
- (c) Determine the size of the image and show the image.
- (d) Convert the image to gray scale and determine the maximum and the minimum value of the image.
- (e) Apply a gaussian smoothing filter (e.g. using the Matlab-functions `conv2`, `fspecial`) and save the output image
- (f) Show 1) the original image, 2) the gray scale image and 3) the filtered image in one figure and give the figures appropriate titles.
- (g) Compare the gray scale image and the filtered image for different values of the smoothing.

2. Basic operations

- (a) Let $A = \begin{pmatrix} 2 & 2 & 0 \\ 0 & 8 & 3 \end{pmatrix}$ and $b = \begin{pmatrix} 5 \\ 15 \end{pmatrix}$. Solve $Ax = b$ for x .
- (b) Define a matrix B equal to A .
- (c) Change the second element in the first row of A to 4.
- (d) Compute the following:

```
c = 0;
for i ∈ {-4, 0, 4}
    c = c + i * AT * b
end
print c
```
- (e) Compare $A \cdot * B$ and $A' * B$ and explain the difference.

3. Write a function `approxequal(x, y, ε)` checking if two vectors x and y are almost equal, i.e. if

$$\forall i : |x_i - y_i| \leq \epsilon.$$

The output should be logical 1 or 0.

If the input consists of two matrices, your function should compare the columns of the matrices if they are almost equal. In this case, the output should be a vector with logical values 1 or 0.

4. Write a function `addprimes(s, e)` returning the sum of all prime numbers between s and e .
Use the Matlab-function `isprime`.