Matgeo Presentation - Problem 1.9.10

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Problem Statement

Given two points

$$\mathbf{A} = \begin{pmatrix} 0 \\ 6 \end{pmatrix}, \mathbf{B} = \begin{pmatrix} 0 \\ -2 \end{pmatrix}.$$

find the distance between them.

Verify results using:

- C implementation
- Python (ctypes + numpy)
- Visualization with matplotlib

solution

solution :

$$\text{Let } \mathbf{A} = \begin{pmatrix} 0 \\ 6 \end{pmatrix}, \quad \mathbf{B} = \begin{pmatrix} 0 \\ -2 \end{pmatrix}. \tag{0.1}$$

$$\text{The distance between } \mathbf{A} \text{ and } \mathbf{B} \text{ is } d(\mathbf{A}, \mathbf{B}) = \|\mathbf{A} - \mathbf{B}\|_2. \tag{0.2}$$

$$\mathbf{A} - \mathbf{B} = \begin{pmatrix} 0 \\ 6 \end{pmatrix} - \begin{pmatrix} 0 \\ -2 \end{pmatrix} = \begin{pmatrix} 0 \\ 8 \end{pmatrix}. \tag{0.3}$$

solution

$$\|\mathbf{A}-\mathbf{B}\|_2 = \sqrt{(\mathbf{A}-\mathbf{B})^T(\mathbf{A}-\mathbf{B})}. \tag{0.4}$$

$$= \sqrt{\begin{pmatrix}0 & 8\end{pmatrix}\begin{pmatrix}0\\8\end{pmatrix}} = \sqrt{0^2+8^2} = \sqrt{64}. \tag{0.5}$$

conclusion : The distance between **A** and **B** is $= 8$. (0.6)

C Source Code: points.c

```
#include <stdio.h>
#include <math.h>

double distance(int x1, int y1, int x2, int y2) {
    return sqrt((x1-x2)*(x1-x2) + (y1-y2)*(y1-y2));
}

void get_points(int *points) {
    points[0] = 0; points[1] = 6;   // A
    points[2] = 0; points[3] = -2;  // B
}
```

Python Script: solve.py

```
import ctypes
# Load shared library
lib = ctypes.CDLL("./libpoints.so")
\# Define argument and return types
lib.distance.argtypes=[ctypes.c_int,ctypes.c_int,ctypes.c_int,
lib.distance.restype = ctypes.c_double
lib.get_points.argtypes = [ctypes.POINTER(ctypes.c_int)]
lib.get_points.restype = None
# Prepare array for points
points = (ctypes.c_int * 4)()
lib.get_points(points)
x1, y1, x2, y2 = points
print(f"Point A = ({x1}, {y1})")
print(f"Point B = ({x2}, {y2})")
\# Get distance
dist = lib.distance(x1, y1, x2, y2)
print(f"Distance between A and B = {dist}")
```

Python Script: plot.py

```
import numpy as np
import matplotlib.pyplot as plt

# Points
A = np.array([0, 6])
B = np.array([0, -2])

# Distance using numpy
dist = np.linalg.norm(A - B)

# Plotting
plt.scatter(A[0], A[1], color="red", label=f"A{tuple(A)}")
plt.scatter(B[0], B[1], color="blue", label=f"B{tuple(B)}")
plt.plot([A[0], B[0]], [A[1], B[1]],
         color="green", linestyle="--",
         label=f"Distance = {dist:.2f}")
```

Python Script: plot.py

```
plt.xlabel("X-axis")
plt.ylabel("Y-axis")
plt.title("Distance between A and B")
plt.legend()
plt.grid(True)
plt.axis("equal")

plt.savefig("points_plot.png", dpi=300)
plt.show()
```

Result Plot