2.8.32

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Question

Ayush starts walking from his house to office. Instead of going to the office directly, he goes to a bankfirst, from there to his daughter school and then reaches the office what is the extra distance travelled by Ayush in reaching his office? If the house is situated at $(2, 4)$,bank at $(5, 8)$, school at $(13, 14)$ and office at $(13, 26)$ and coordinates are in km.

Variables Taken

H	$\begin{pmatrix} 2 \\ 4 \end{pmatrix}$
B	$\begin{pmatrix} 5 \\ 8 \end{pmatrix}$
S	$\begin{pmatrix} 13 \\ 14 \end{pmatrix}$
O	$\begin{pmatrix} 13 \\ 26 \end{pmatrix}$

Theoretical Solution

Let us solve the given equation theoretically and then verify the solution computationally.

To calculate the extra ditsance travelled by Ayush, let d_1 be the distance from his home to office

$$d_1 = ||\mathbf{O} - \mathbf{H}|| \tag{1}$$

$$= \sqrt{\left(\mathbf{O} - \mathbf{H}\right)^{\top} \left(\mathbf{O} - \mathbf{H}\right)} \tag{2}$$

$$= \sqrt{605}\,\text{km}\,(\approx 24.59) \tag{3}$$

Theoretical Solution

Let d_2 be the actual distance travelled by Ayush,

$$d_2 = ||\mathbf{B}-\mathbf{H}|| + ||\mathbf{S}-\mathbf{B}|| + ||\mathbf{O}-\mathbf{S}|| \tag{4}$$

$$= \sqrt{\left(\mathbf{B}-\mathbf{H}\right)^{\top}\left(\mathbf{B}-\mathbf{H}\right)} + \sqrt{\left(\mathbf{S}-\mathbf{B}\right)^{\top}\left(\mathbf{S}-\mathbf{B}\right)} + \tag{5}$$

$$\sqrt{\left(\mathbf{O}-\mathbf{S}\right)^{\top}\left(\mathbf{O}-\mathbf{S}\right)} \tag{6}$$

$$= 27\text{km} \tag{7}$$

The extra distance travelled is,

$$d_2 - d_1 = 27 - 24.59 \tag{8}$$

$$= 2.41\ (\approx 2.4\text{km}) \tag{9}$$

C code

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

// Function to calculate distance between two points
double distance(int x1, int y1, int x2, int y2) {
    return sqrt(pow(x2 - x1, 2) + pow(y2 - y1, 2));
}
```

Call C.py

```
import numpy as np
import numpy.linalg as LA
import matplotlib.pyplot as plt
import matplotlib.image as mpimg

# Load shared library
if platform.system() == "Windows":
    dist_lib = ctypes.CDLL("./distance.dll")
else:
    dist_lib = ctypes.CDLL("./distance.so")

# Function signature
dist_lib.extra_distance.argtypes = [ctypes.c_int, ctypes.c_int,
    ctypes.c_int, ctypes.c_int,
                                    ctypes.c_int, ctypes.c_int,
                                        ctypes.c_int, ctypes.c_int]
dist_lib.extra_distance.restype = ctypes.c_double
```

Call C.py

```
# Call the C function
extra = dist_lib.extra_distance(2, 4, # house
                                5, 8, # bank
                                13, 14, # school
                                13, 26) # office

print("Extra distance travelled:", extra, "km")
```

Plot.py

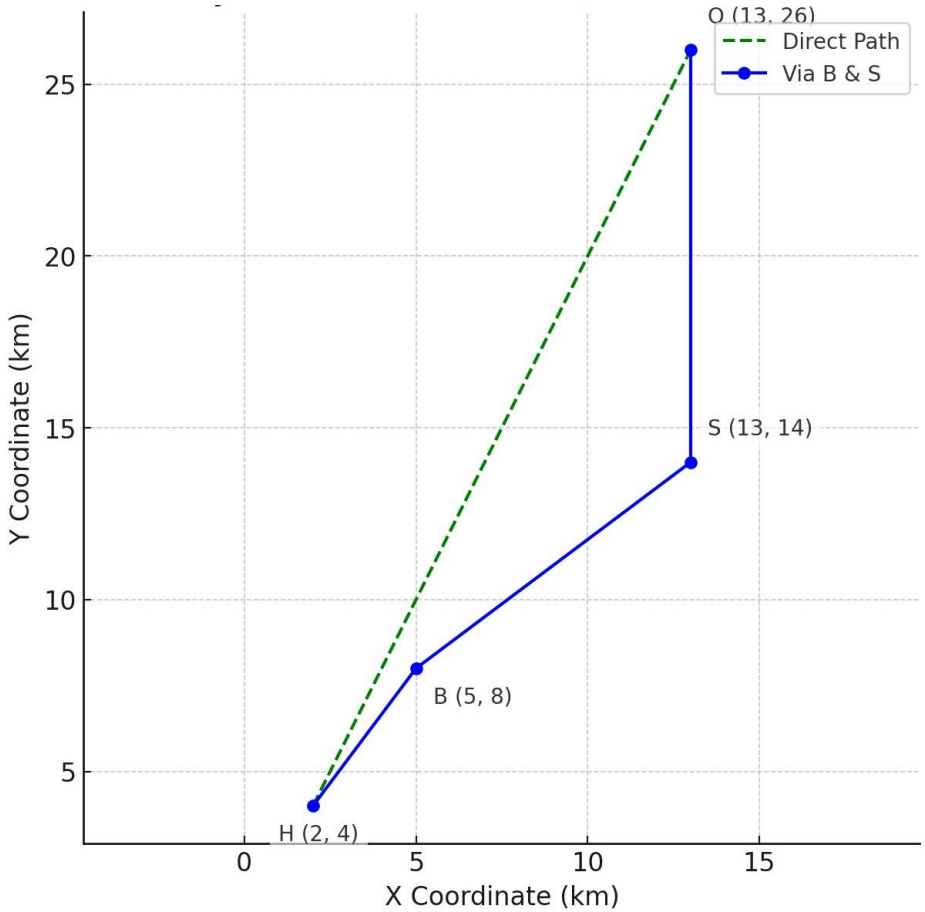
```
import numpy as np
import numpy.linalg as LA
import matplotlib.pyplot as plt
import matplotlib.image as mpimg

# Coordinates
H = (2, 4)
B = (5, 8)
S = (13, 14)
O = (13, 26)

# Path via B & S
x_via = [H[0], B[0], S[0], O[0]]
y_via = [H[1], B[1], S[1], O[1]]

# Direct Path
x_direct = [H[0], O[0]]
y_direct = [H[1], O[1]]
```

Plot.py

```
# Plot direct path (green dashed)
plt.plot(x_direct, y_direct, 'g--', label="Direct Path")

# Label points
for point, name in zip([H, B, S, O], ['H', 'B', 'S', 'O']):
    plt.text(point[0]+0.3, point[1], f"{name} {point}", fontsize
        =10)

# Labels
plt.xlabel("X Coordinate (km)")
plt.ylabel("Y Coordinate (km)")
plt.title("Paths between H and O")
plt.legend()
plt.grid(True)

plt.show()
```

Plot

From the graph, theoretical solution matches with the computational solution.



Ayush's path to Office