1. Compute the cost matrix

Inputs

$$\mathbf{X} = \{3,9,8\}$$

$$\mathbf{Y} = \{3,1,9,9,7,8\}$$

$$\mathbf{C} = \begin{bmatrix} & \\ & \end{bmatrix}$$

1. Compute the cost matrix

Inputs

$$\mathbf{X} = \{3,9,8\}$$

$$\mathbf{Y} = \{3,1,9,9,7,8\}$$

$$C_{11} = |x_1 - y_1| = |3 - 3| = 0$$

$$\mathbf{C} = \begin{bmatrix} 0 & & & & & \\ & & & & & \\ & & & & & \end{bmatrix}$$

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Inputs

$$\mathbf{X} = \{3,9,8\}$$

$$\mathbf{Y} = \{3,1,9,9,7,8\}$$

$$C_{11} = |x_1 - y_1| = |3 - 3| = 0$$
$$C_{12} = |x_1 - y_2| = |3 - 1| = 2$$

$$\mathbf{C} = \begin{bmatrix} 0 & 2 \\ & \\ & \end{bmatrix}$$

1. Compute the cost matrix

Inputs

$$\mathbf{X} = \{3,9,8\}$$

$$\mathbf{Y} = \{3,1,9,9,7,8\}$$

$$C_{11} = |x_1 - y_1| = |3 - 3| = 0$$
$$C_{12} = |x_1 - y_2| = |3 - 1| = 2$$
$$C_{13} = |x_1 - y_3| = |3 - 9| = 6$$

$$\mathbf{C} = \begin{bmatrix} 0 & 2 & 6 \\ & & \\ & & \end{bmatrix}$$

1. Compute the cost matrix

Inputs

$$\mathbf{X} = \{3,9,8\}$$

$$\mathbf{Y} = \{3,1,9,9,7,8\}$$

$$C_{11} = |x_1 - y_1| = |3 - 3| = 0$$
$$C_{12} = |x_1 - y_2| = |3 - 1| = 2$$
$$C_{13} = |x_1 - y_3| = |3 - 9| = 6$$
$$C_{14} = |x_1 - y_4| = |3 - 9| = 6$$

$$\mathbf{C} = \begin{bmatrix} 0 & 2 & 6 & 6 \\ & & & \\ & & & \end{bmatrix}$$

1. Compute the cost matrix

Inputs

$$\mathbf{X} = \{3,9,8\}$$

$$\mathbf{Y} = \{3,1,9,9,7,8\}$$

$$C_{11} = |x_1 - y_1| = |3 - 3| = 0$$
$$C_{12} = |x_1 - y_2| = |3 - 1| = 2$$
$$C_{13} = |x_1 - y_3| = |3 - 9| = 6$$
$$C_{14} = |x_1 - y_4| = |3 - 9| = 6$$
$$C_{15} = |x_1 - y_5| = |3 - 7| = 4$$

$$\mathbf{C} = \begin{bmatrix} 0 & 2 & 6 & 6 & 4 \\ & & & & \end{bmatrix}$$

1. Compute the cost matrix

Inputs

$$\mathbf{X} = \{3,9,8\}$$

$$\mathbf{Y} = \{3,1,9,9,7,8\}$$

$$C_{11} = |x_1 - y_1| = |3 - 3| = 0$$
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$$C_{14} = |x_1 - y_4| = |3 - 9| = 6$$
$$C_{15} = |x_1 - y_5| = |3 - 7| = 4$$
$$C_{16} = |x_1 - y_6| = |3 - 8| = 5$$

$$\mathbf{C} = \begin{bmatrix} 0 & 2 & 6 & 6 & 4 & 5 \\ & & & & & \end{bmatrix}$$

1. Compute the cost matrix

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$$\mathbf{Y} = \{3,1,9,9,7,8\}$$

$$C_{11} = |x_1 - y_1| = |3 - 3| = 0$$
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$$C_{14} = |x_1 - y_4| = |3 - 9| = 6$$
$$C_{15} = |x_1 - y_5| = |3 - 7| = 4$$
$$C_{16} = |x_1 - y_6| = |3 - 8| = 5$$

$$\mathbf{C} = \begin{bmatrix} 0 & 2 & 6 & 6 & 4 & 5 \\ 6 & 8 & 0 & 0 & 2 & 1 \\ 5 & 7 & 1 & 1 & 1 & 0 \end{bmatrix}$$

2. Compute the accumulated cost matrix

Inputs

$$\mathbf{X} = \{3,9,8\}$$

$$\mathbf{Y} = \{3,1,9,9,7,8\}$$

Initialization

$$D_{i,1} = \sum_{k=1}^{i} C_{k,1} \qquad D_{1,i} = \sum_{k=1}^{i} C_{1,k}$$

Iteration

$$D_{ij} = C_{ij} + \min(D_{j-1,i-1}, D_{i-1,j}, D_{i,j-1})$$

$$\mathbf{C} = \begin{bmatrix} 0 & 2 & 6 & 6 & 4 & 5 \\ 6 & 8 & 0 & 0 & 2 & 1 \\ 5 & 7 & 1 & 1 & 1 & 0 \end{bmatrix}$$

$$\mathbf{D} = \begin{bmatrix} & & & & & \\ & & & & & \\ & & & & & \end{bmatrix}$$

2. Compute the accumulated cost matrix

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Iteration

$$D_{ij} = C_{ij} + \min(D_{j-1,i-1}, D_{i-1,j}, D_{i,j-1})$$

$$\mathbf{C} = \begin{bmatrix} 0 & 2 & 6 & 6 & 4 & 5 \\ 6 & 8 & 0 & 0 & 2 & 1 \\ 5 & 7 & 1 & 1 & 1 & 0 \end{bmatrix}$$

$$\mathbf{D} = \begin{bmatrix} 0 \\ 6 \\ 11 \end{bmatrix}$$

2. Compute the accumulated cost matrix

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$$\mathbf{X} = \{3,9,8\}$$

$$\mathbf{Y} = \{3,1,9,9,7,8\}$$

Initialization

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Iteration

$$D_{ij} = C_{ij} + \min(D_{j-1,i-1}, D_{i-1,j}, D_{i,j-1})$$

$$\mathbf{C} = \begin{bmatrix} 0 & 2 & 6 & 6 & 4 & 5 \\ 6 & 8 & 0 & 0 & 2 & 1 \\ 5 & 7 & 1 & 1 & 1 & 0 \end{bmatrix}$$

$$\mathbf{D} = \begin{bmatrix} 0 & 2 & 8 & 14 & 18 & 23 \\ 6 & & & & & \\ 11 & & & & & \end{bmatrix}$$

2. Compute the accumulated cost matrix

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Iteration

$$D_{ij} = C_{ij} + \min(D_{j-1,i-1}, D_{i-1,j}, D_{i,j-1})$$

$$D_{22} = C_{22} + \min(D_{2-1,2-1}, D_{2-1,2}, D_{2,2-1}) = 8 + \min(0,2,6) = 8$$

$$\mathbf{C} = \begin{bmatrix} 0 & 2 & 6 & 6 & 4 & 5 \\ 6 & 8 & 0 & 0 & 2 & 1 \\ 5 & 7 & 1 & 1 & 1 & 0 \end{bmatrix}$$

$$\mathbf{D} = \begin{bmatrix} 0 & 2 & 8 & 14 & 18 & 23 \\ 6 & 8 & & & & \\ 11 & & & & & \end{bmatrix}$$

2. Compute the accumulated cost matrix

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$$D_{23} = C_{23} + \min(D_{2-1,3-1}, D_{2-1,3}, D_{2,3-1}) = 0 + \min(2,8,8) = 2$$

$$\mathbf{D} = \begin{bmatrix} 0 & 2 & 8 & 14 & 18 & 23 \\ 6 & 8 & 2 & & & \\ 11 & & & & & \end{bmatrix}$$

2. Compute the accumulated cost matrix

Inputs

$$\mathbf{X} = \{3,9,8\}$$

$$\mathbf{Y} = \{3,1,9,9,7,8\}$$

Initialization

$$D_{i,1} = \sum_{k=1}^{i} C_{k,1}$$

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Iteration

$$D_{ij} = C_{ij} + \min(D_{j-1,i-1}, D_{i-1,j}, D_{i,j-1})$$

$$\mathbf{C} = \begin{bmatrix} 0 & 2 & 6 & 6 & 4 & 5 \\ 6 & 8 & 0 & 0 & 2 & 1 \\ 5 & 7 & 1 & 1 & 1 & 0 \end{bmatrix}$$

$$D_{22} = C_{22} + \min(D_{2-1,2-1}, D_{2-1,2}, D_{2,2-1}) = 8 + \min(0,2,6) = 8$$

$$D_{23} = C_{23} + \min(D_{2-1,3-1}, D_{2-1,3}, D_{2,3-1}) = 0 + \min(2,8,8) = 2$$

$$D_{24} = C_{24} + \min(D_{2-1,4-1}, D_{2-1,4}, D_{2,4-1}) = 0 + \min(8,14,2) = 2$$

$$\mathbf{D} = \begin{bmatrix} 0 & 2 & 8 & 14 & 18 & 23 \\ 6 & 8 & 2 & 2 & & \\ 11 & & & & & \end{bmatrix}$$

2. Compute the accumulated cost matrix

Inputs

$$\mathbf{X} = \{3,9,8\}$$

$$\mathbf{Y} = \{3,1,9,9,7,8\}$$

Initialization

$$D_{i,1} = \sum_{k=1}^{i} C_{k,1} \qquad D_{1,i} = \sum_{k=1}^{i} C_{1,k}$$

Iteration

$$D_{ij} = C_{ij} + \min(D_{j-1,i-1}, D_{i-1,j}, D_{i,j-1})$$

$$\mathbf{C} = \begin{bmatrix} 0 & 2 & 6 & 6 & 4 & 5 \\ 6 & 8 & 0 & 0 & 2 & 1 \\ 5 & 7 & 1 & 1 & 1 & 0 \end{bmatrix}$$

$$D_{22} = C_{22} + \min(D_{2-1,2-1}, D_{2-1,2}, D_{2,2-1}) = 8 + \min(0,2,6) = 8$$

$$D_{23} = C_{23} + \min(D_{2-1,3-1}, D_{2-1,3}, D_{2,3-1}) = 0 + \min(2,8,8) = 2$$

$$D_{24} = C_{24} + \min(D_{2-1,4-1}, D_{2-1,4}, D_{2,4-1}) = 0 + \min(8,14,2) = 2$$

$$D_{25} = C_{25} + \min(D_{2-1,5-1}, D_{2-1,5}, D_{2,5-1}) = 2 + \min(14,18,2) = 4$$

$$\mathbf{D} = \begin{bmatrix} 0 & 2 & 8 & 14 & 18 & 23 \\ 6 & 8 & 2 & 2 & 4 & \\ 11 & & & & & \end{bmatrix}$$

2. Compute the accumulated cost matrix

Inputs

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$$D_{i,1} = \sum_{k=1}^{i} C_{k,1} \qquad D_{1,i} = \sum_{k=1}^{i} C_{1,k}$$

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$$D_{ij} = C_{ij} + \min(D_{j-1,i-1}, D_{i-1,j}, D_{i,j-1})$$

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$$D_{22} = C_{22} + \min(D_{2-1,2-1}, D_{2-1,2}, D_{2,2-1}) = 8 + \min(0,2,6) = 8$$

$$D_{23} = C_{23} + \min(D_{2-1,3-1}, D_{2-1,3}, D_{2,3-1}) = 0 + \min(2,8,8) = 2$$

$$D_{24} = C_{24} + \min(D_{2-1,4-1}, D_{2-1,4}, D_{2,4-1}) = 0 + \min(8,14,2) = 2$$

$$D_{25} = C_{25} + \min(D_{2-1,5-1}, D_{2-1,5}, D_{2,5-1}) = 2 + \min(14,18,2) = 4$$

$$D_{26} = C_{26} + \min(D_{2-1,6-1}, D_{2-1,6}, D_{2,6-1}) = 1 + \min(18,23,4) = 5$$

$$\mathbf{D} = \begin{bmatrix} 0 & 2 & 8 & 14 & 18 & 23 \\ 6 & 8 & 2 & 2 & 4 & 5 \\ 11 & & & & & \end{bmatrix}$$

2. Compute the accumulated cost matrix

Inputs

$$\mathbf{X} = \{3,9,8\}$$

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Initialization

$$D_{i,1} = \sum_{k=1}^{i} C_{k,1} \qquad D_{1,i} = \sum_{k=1}^{i} C_{1,k}$$

Iteration

$$D_{ij} = C_{ij} + \min(D_{j-1,i-1}, D_{i-1,j}, D_{i,j-1})$$

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$$D_{25} = C_{25} + \min(D_{2-1,5-1}, D_{2-1,5}, D_{2,5-1}) = 2 + \min(14,18,2) = 4$$

$$D_{26} = C_{26} + \min(D_{2-1,6-1}, D_{2-1,6}, D_{2,6-1}) = 1 + \min(18,23,4) = 5$$

$$\mathbf{D} = \begin{bmatrix} 0 & 2 & 8 & 14 & 18 & 23 \\ 6 & 8 & 2 & 2 & 4 & 5 \\ 11 & 13 & 3 & 3 & 3 & 3 \end{bmatrix}$$

3. Get warping path via backtracking

Inputs

$\mathbf{X} = \{3,9,8\}$

$\mathbf{Y} = \{3,1,9,9,7,8\}$

$$\mathbf{D} = \begin{bmatrix} 0 & 2 & 8 & 14 & 18 & 23 \\ 6 & 8 & 2 & 2 & 4 & 5 \\ 11 & 13 & 3 & 3 & 3 & 3 \end{bmatrix}$$

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$$\mathbf{D} = \begin{bmatrix} 0 & 2 & 8 & 14 & 18 & 23 \\ 6 & 8 & 2 & 2 & 4 & 5 \\ 11 & 13 & 3 & 3 & 3 & 3 \end{bmatrix}$$

$q_1 = (3,6)$

3. Get warping path via backtracking

Inputs

$\mathbf{X} = \{3,9,8\}$

$\mathbf{Y} = \{3,1,9,9,7,8\}$

$$\mathbf{D} = \begin{bmatrix} 0 & 2 & 8 & 14 & 18 & 23 \\ 6 & 8 & 2 & 2 & 4 & 5 \\ 11 & 13 & 3 & 3 & 3 & 3 \end{bmatrix}$$

$q_1 = (3,6)$

$q_2 = \arg\min(D_{3-1,6-1}, D_{3,6-1}, D_{3-1,6}) = (3,5)$

3. Get warping path via backtracking

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$\mathbf{X} = \{3,9,8\}$

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$q_3 = \arg\min(D_{3-1,5-1}, D_{3,5-1}, D_{3-1,5}) = (2,4)$

3. Get warping path via backtracking

Inputs

$\mathbf{X} = \{3,9,8\}$

$\mathbf{Y} = \{3,1,9,9,7,8\}$

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3. Get warping path via backtracking

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$q_1 = (3,6)$

$q_2 = \arg\min(D_{3-1,6-1}, D_{3,6-1}, D_{3-1,6}) = (3,5)$

$q_3 = \arg\min(D_{3-1,5-1}, D_{3,5-1}, D_{3-1,5}) = (2,4)$

$q_4 = \arg\min(D_{2-1,4-1}, D_{2,4-1}, D_{2-1,4}) = (2,3)$

3. Get warping path via backtracking

Inputs

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$$\mathbf{D} = \begin{bmatrix} 0 & 2 & 8 & 14 & 18 & 23 \\ 6 & 8 & 2 & 2 & 4 & 5 \\ 11 & 13 & 3 & 3 & 3 & 3 \end{bmatrix}$$

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$q_4 = \arg\min(D_{2-1,4-1}, D_{2,4-1}, D_{2-1,4}) = (2,3)$

3. Get warping path via backtracking

Inputs

$\mathbf{X} = \{3,9,8\}$

$\mathbf{Y} = \{3,1,9,9,7,8\}$

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$q_1 = (3,6)$

$q_2 = \arg\min(D_{3-1,6-1}, D_{3,6-1}, D_{3-1,6}) = (3,5)$

$q_3 = \arg\min(D_{3-1,5-1}, D_{3,5-1}, D_{3-1,5}) = (2,4)$

$q_4 = \arg\min(D_{2-1,4-1}, D_{2,4-1}, D_{2-1,4}) = (2,3)$

$q_5 = \arg\min(D_{2-1,3-1}, D_{2,3-1}, D_{2-1,3}) = (1,2)$

3. Get warping path via backtracking

Inputs

$\mathbf{X} = \{3,9,8\}$

$\mathbf{Y} = \{3,1,9,9,7,8\}$

$$\mathbf{D} = \begin{bmatrix} 0 & 2 & 8 & 14 & 18 & 23 \\ 6 & 8 & 2 & 2 & 4 & 5 \\ 11 & 13 & 3 & 3 & 3 & 3 \end{bmatrix}$$

$q_1 = (3,6)$

$q_2 = \arg\min(D_{3-1,6-1}, D_{3,6-1}, D_{3-1,6}) = (3,5)$

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$q_4 = \arg\min(D_{2-1,4-1}, D_{2,4-1}, D_{2-1,4}) = (2,3)$

$q_5 = \arg\min(D_{2-1,3-1}, D_{2,3-1}, D_{2-1,3}) = (1,2)$

3. Get warping path via backtracking

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$q_1 = (3,6)$

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$q_3 = \arg\min(D_{3-1,5-1}, D_{3,5-1}, D_{3-1,5}) = (2,4)$

$q_4 = \arg\min(D_{2-1,4-1}, D_{2,4-1}, D_{2-1,4}) = (2,3)$

$q_5 = \arg\min(D_{2-1,3-1}, D_{2,3-1}, D_{2-1,3}) = (1,2)$

$q_6 = (1, q_5[1] - 1) = (1,1)$

3. Get warping path via backtracking

Inputs

$\mathbf{X} = \{3,9,8\}$

$\mathbf{Y} = \{3,1,9,9,7,8\}$

$$\mathbf{D} = \begin{bmatrix} 0 & 2 & 8 & 14 & 18 & 23 \\ 6 & 8 & 2 & 2 & 4 & 5 \\ 11 & 13 & 3 & 3 & 3 & 3 \end{bmatrix}$$

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$q_4 = \arg\min(D_{2-1,4-1}, D_{2,4-1}, D_{2-1,4}) = (2,3)$

$q_5 = \arg\min(D_{2-1,3-1}, D_{2,3-1}, D_{2-1,3}) = (1,2)$

$q_6 = (1, q_5[1] - 1) = (1,1)$

3. Get warping path via backtracking

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$q_4 = \arg\min(D_{2-1,4-1}, D_{2,4-1}, D_{2-1,4}) = (2,3)$

$q_5 = \arg\min(D_{2-1,3-1}, D_{2,3-1}, D_{2-1,3}) = (1,2)$

$q_6 = (1, q_5[1] - 1) = (1,1)$

$$\mathbf{P}^* = \{(1,1), (1,2), (2,3), (2,4), (3,5), (3,6)\}$$