

## Exercise sheet 2: Edit operations and alignments

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### Exercise 1 - Levenshtein Distance

Compute the minimal Levenshtein edit distance for the following pairs of sequences.

1a)

$$S_1 = A \tag{1}$$

$$S_2 = T \tag{2}$$

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**Hint**  $A \rightarrow T$

**Correct Answer**  $A \rightarrow T = 1$

1b)

$$S_1 = AGATATA \tag{3}$$

$$S_2 = TATATATA \tag{4}$$

**Hide**

**Hint**  $AGATATA \rightarrow ATATATA \rightarrow \dots$

**Correct Answer**  $AGATATA \rightarrow ATATATA \rightarrow TATATATA = 3$

1c)

$$S_1 = AGTCCT \tag{5}$$

$$S_2 = CGCTCA \tag{6}$$

**Hide**

**Hint** AGTCCT  $\rightarrow$  AGCTCA  $\rightarrow \dots$

**Correct Answer** AGTCCT  $\rightarrow$  CGTCCT  $\rightarrow$  CGCCCT  $\rightarrow$  CGCTCA = 4

1d)

$$S_1 = TGCATAT \quad (7)$$

$$S_2 = ATCCGAT \quad (8)$$

**Hide**

**Hint** TGCATAT  $\rightarrow$  AGCATAT  $\rightarrow \dots$

**Correct Answer** TGCATAT  $\rightarrow$  AGCATAT  $\rightarrow$  ATCATAT  $\rightarrow$  ATCCGAT = 4

1e)

$$S_1 = ACGTATATAGCCCCGCG \quad (9)$$

$$S_2 = ACGTTATATAGCCGCGC \quad (10)$$

**Hide**

**Hint** You need to use all the possible operations

ACGTATATAGCCCCGCG  $\rightarrow$  ACGTTATATAGCCCCGCG  $\rightarrow \dots$

**Correct Answer** ACGTATATAGCCCCGCG  $\rightarrow$  ACGTTATATAGCCCCGCG  $\rightarrow$  ACGTTATATAGCCGCGC  $\rightarrow$  ACGTTATATAGCCGCGC = 4

## Exercise 2 - Metric function

Check if the corresponding functions are metric.

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## Formulae Note

Definition Metric:

$$w(x, y) = 0 \leftrightarrow x = y \quad (\text{identity}) \quad (11)$$

$$w(x, y) = w(y, x) \quad (\text{symmetric}) \quad (12)$$

$$w(x, z) \leq w(x, y) + w(y, z) \quad (\text{triangle inequality}) \quad (13)$$

2a)

$$w(x, y) = x - y \quad (14)$$

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**Hint** What if  $x = 1$  and  $y = 2$ ?

**Correct Answer** Not a metric, violates identity constraint.

$$x - y = 1 - 2 = -1 \neq 1 = 2 - 1 = y - x$$

2b)

$$w(x, y) = |x - y| \quad (15)$$

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**Hint** You need to check all the properties.

**Correct Answer** Metric

2c)

$$w(x, y) = x + y \quad (16)$$

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**Hint** What if  $x = 1$  and  $y = 1$ ?

**Correct Answer** Not metric, violates symmetry constraint:

$$x = y = 1 \Rightarrow x + y = 1 + 1 = 2 \neq 0$$

2d)

$$w(x, y) = \begin{cases} 1 & \text{if } x \neq y \\ 0 & \text{else} \end{cases} \quad (17)$$

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**Hint** You need to check all the properties.

**Correct Answer** Metric

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## Exercise 3 - Programming assignment

Programming assignments are available via Github Classroom and contain automatic tests.

We recommend doing these assignments since they will help you to further understand this topic.

Access the Github Classroom link: [Programming Assignment: Sheet 02](#).

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