

## Exercise sheet 2: Edit operations and alignments

---

### Exercise 1 - Levenshtein Distance

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

1a)

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

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

**Hide**

**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**  $AGATATA \rightarrow ATATATA \rightarrow TATATATA = 2$

1c)

$$S_1 = AGTCCT \quad (5)$$

$$S_2 = CGCTCA \quad (6)$$

**Hide**

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

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

1d)

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

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

**Hide**

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

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

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  $\rightarrow$  ACGTTATATAGC-  
CGCGCG  $\rightarrow$  ACGTTATATAGCCGCGC = 3

## Exercise 2 - Metric function

Check if the corresponding functions are metric.

**Hide**

### 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)**

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

**Hide**

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

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

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

**2b)**

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

**Hide**

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

**Correct Answer** Metric

**2c)**

$$w(x, y) = x + y \tag{16}$$

**Hide**

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

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

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

**2d)**

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

**Hide**

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

**Correct Answer** Metric

---

## 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](#).

---