Exercise sheet 2: Edit operations and alignments

Exercise 1 - Levenshtein Distance

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

1a)

$$S_1 = A \tag{1}$$
$$S_2 = T \tag{2}$$

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Hint A $\rightarrow$ T

Solution A $\rightarrow$ T = 1

1b)

$$S_1 = AGATATA \tag{3}$$
$$S_2 = TATATATA \tag{4}$$

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Hint AGATATA $\rightarrow$ ATATATA $\rightarrow \ldots$

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

1c)

$$S_1 = AGTCCT \tag{5}$$
$$S_2 = CGCTCA \tag{6}$$

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Hint AGTCCT → AGCTCA → ...

Solution AGTCCT → CGTCCT → CGCCCT → CGCTCT → CGCTCA = 4

1d)

$$S_1 = TGCATAT \tag{7}$$
$$S_2 = ATCCGAT \tag{8}$$

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Hint TGCATAT → AGCATAT → ...

Solution TGCATAT → AGCATAT → ATCATAT → ATCAGAT → ATCCGAT = 4

1e)

$$S_1 = ACGTATATAGCCCCGCG \tag{9}$$
$$S_2 = ACGTTATATAGCCGCGC \tag{10}$$

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Hint You need to use all the possible operations

ACGTATATAGCCCCGCG → ACGTTATATAGCCCCGCG → ...

Solution ACGTATATAGCCCCGCG → ACGTTATATAGCCCCGCG → ACGTTATATAGCCGCGCG → ACGTTATATAGCCGCGC = 3

Exercise 2 - Metric function

Check if the corresponding functions are metric.

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Formulae Note

Definition Metric:

$$w(x,y) = 0 \leftrightarrow x = y \quad \text{(identity)} \tag{11}$$
$$w(x,y) = w(y,x) \quad \text{(symmetric)} \tag{12}$$
$$w(x,z) \leq w(x,y) + w(y,z) \quad \text{(triangle inequality)} \tag{13}$$

2a)

$$w(x,y) = x - y \tag{14}$$

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

Solution Not a metric, violates symmetry constraint.

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

2b)

$$w(x,y) = |x - y| \tag{15}$$

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Hint You need to check all the properties.

Solution Metric

2c)

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

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

Solution Not metric, violates identity constraint:

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

2d)

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

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Hint You need to check all the properties.

Solution 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.
