Mining and Processing Biomedical Data

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Preprocessing Time Series

Time Series

- Sequence of numbers:

  10, 12, 13 …

- Example: observation of the temperature

  6:00 am – 10 ºC
  7:00 am – 12 ºC
  8:00 am – 13 ºC
  9:00 am – 15 ºC
  ...

Multivariate Time Series

- Electrocardiograph (ECG) and Electroencephalograph (EEG) signals
- Several values (observations) at each point of time

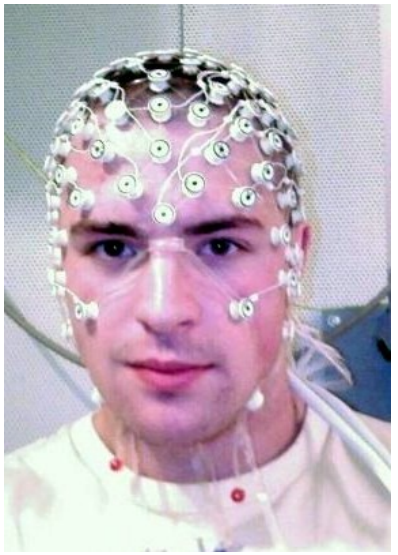

Image: http://en.wikipedia.org/wiki/File:EEG_cap.jpg

Excerpt from the publicly available EEG database at https://archive.ics.uci.edu/ml/datasets/EEG+Database

Time point	Senor 1	Sensor 2	Sensor 3	Sensor 4	Sensor 5	...
1	-8.921	0.834	-19.847	8.148	-2.146	...
2	-8.433	3.276	-12.522	1.801	-2.146	...
3	-2.574	5.717	1.149	-2.594	-1.658	...
4	5.239	7.67	14.821	-4.547	-0.682	...
5	11.587	9.623	20.681	-5.035	2.248	...
...	...	...	...	...	...	...

Nearest Neighbor Classification of Time Series

- How to compare two time series?

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- Compare the values one by one:

first time series:	-1.34	-2	3.5	1.7	...
second time series:	0.32	-1.5	2.8	0.9	...

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- Problems with this simple approach
  - *What if time series are of different length?*
  - *Shiftings and elongations*, i.e., patterns reflecting real-world phenomena may have various length and may begin at (slightly) different position of the time-series
  - *Noise*

Preprocessing of Time Series

- Fourier transformation
- Aggregation of consequitve values
- Transformation to a symbolic representation
- Moving average
- Normalisation
- ...

Aggregation of consequtive values

- Time series:

- Aggregated time-series:

1.63 , 2.4 , ...

(Average of the first 10 values)

(Average of the next 10 values)

Aggregation of consequtive values

- Time series:

1.0, 1.2, 1.3, 1.7, 1.7, 1.8, 1.8, 1.9, 1.9, 2.0, 2.1 2.2 …

- Aggregated time-series:

1.63 , 2.4 , ...

(Average of the first 10 values)

(Average of the next 10 values)

- Symbolic representation

B , C , ...

0..1	1..2	2..3	...
A	B	C	...

Moving Average

- Time series:

1.0, 1.2, 1.3, 1.7, 1.7, 1.8, 1.8, 1.9, 1.9, 2.0, 2.1 2.2 …

- Transformed time-series:

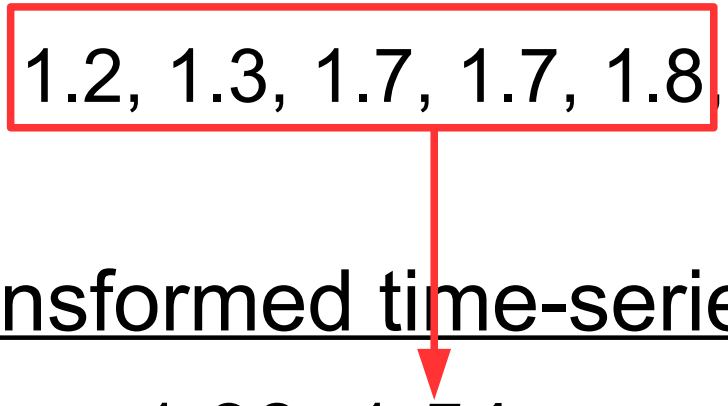
1.38

(Average of the first 5 values)

Moving Average

- Time series:

1.0, 1.2, 1.3, 1.7, 1.7, 1.8, 1.8, 1.9, 1.9, 2.0, 2.1 2.2 …



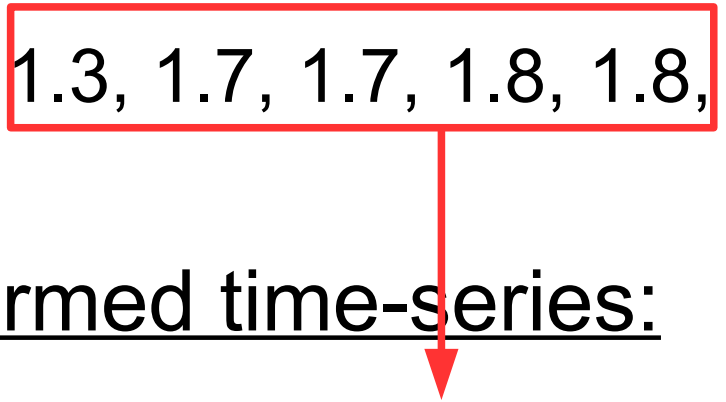
- Transformed time-series:

1.38, 1.54,

Moving Average

- Time series:

1.0, 1.2, 1.3, 1.7, 1.7, 1.8, 1.8, 1.9, 1.9, 2.0, 2.1 2.2 …



- Transformed time-series:

1.38, 1.54, ...

Normalisation

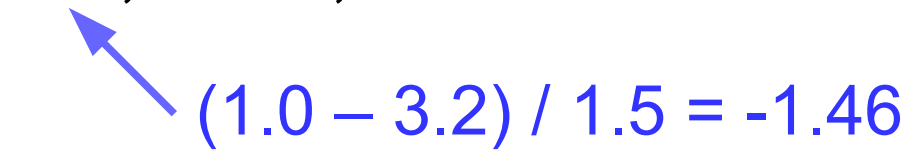
- Time series:

  1.0, 1.2, 1.3, 1.7, 1.7, 1.8, 1.8, 1.9, 1.9, 2.0, 2.1 2.2 …

- Average of all the values: 3.2
  Standard deviation of all the values: 1.5

- Normalised time-series:

  -1.46, -1.33, -1.26 ...



Dynamic Time Warping (DTW)

Proximity measures for time series

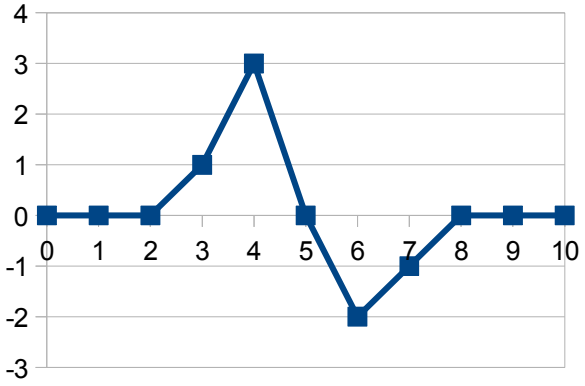
- Similarity measures and distance measure
- Similarity measure
  - High value → two time series are similar
  - Low value → two time series are different
- Distance measure
  - High value → two time series are different (dissimilar)
  - Low value → two time series are similar
- Dynamic Time Warping (DTW) is a distance measure

Example

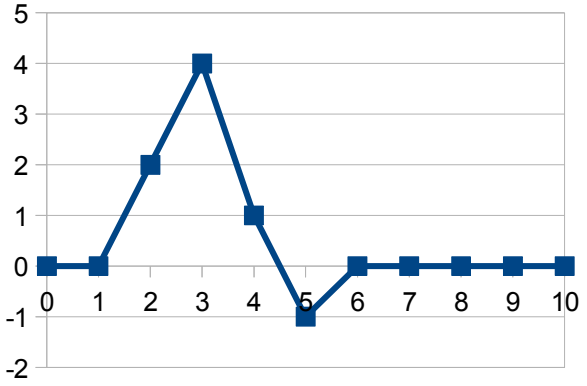
x*: 0, 0, 0, 1, 3, 0, -2, -1, 0, 0, 0

x1: 0, 0, 2, 4, 1, -1, 0, 0, 0, 0, 0

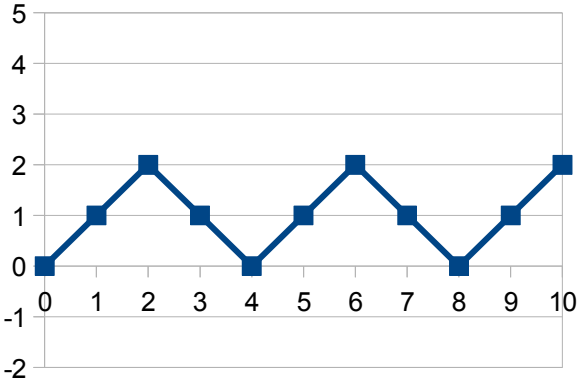
x2: 0, 1, 2, 1, 0, 1, 2, 1, 0, 1, 2



x*

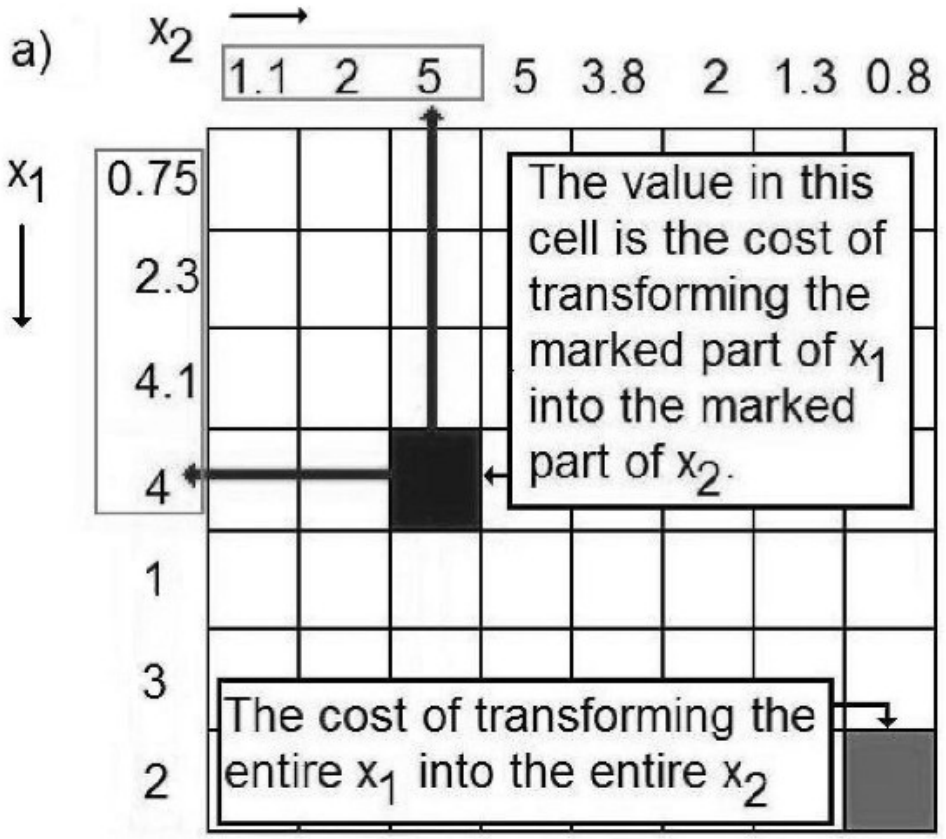


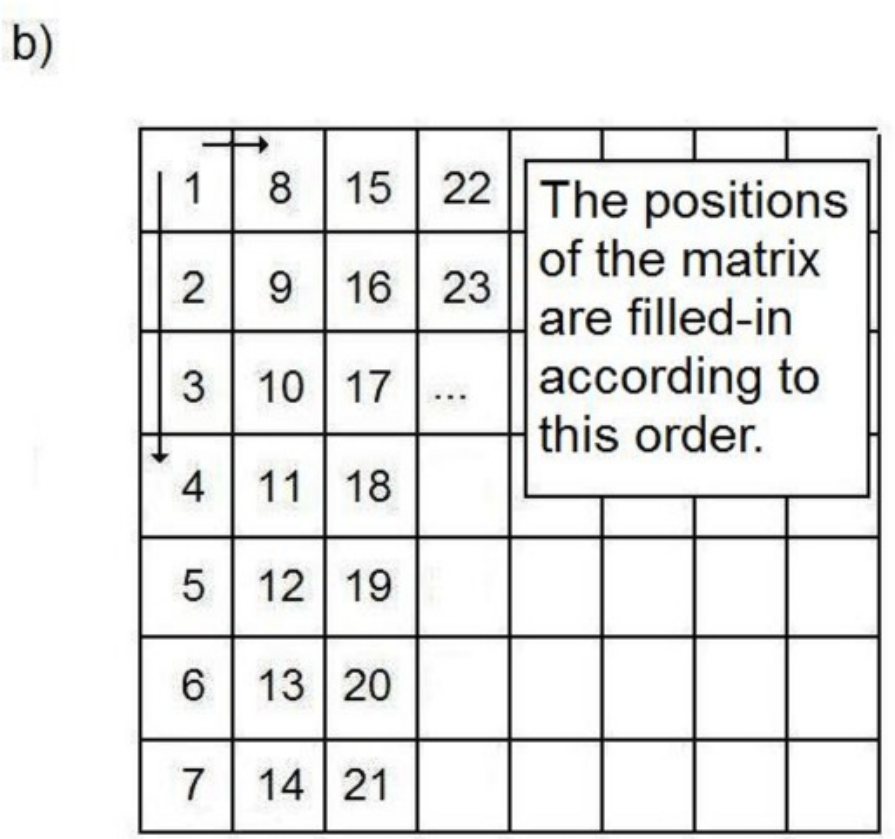
x1



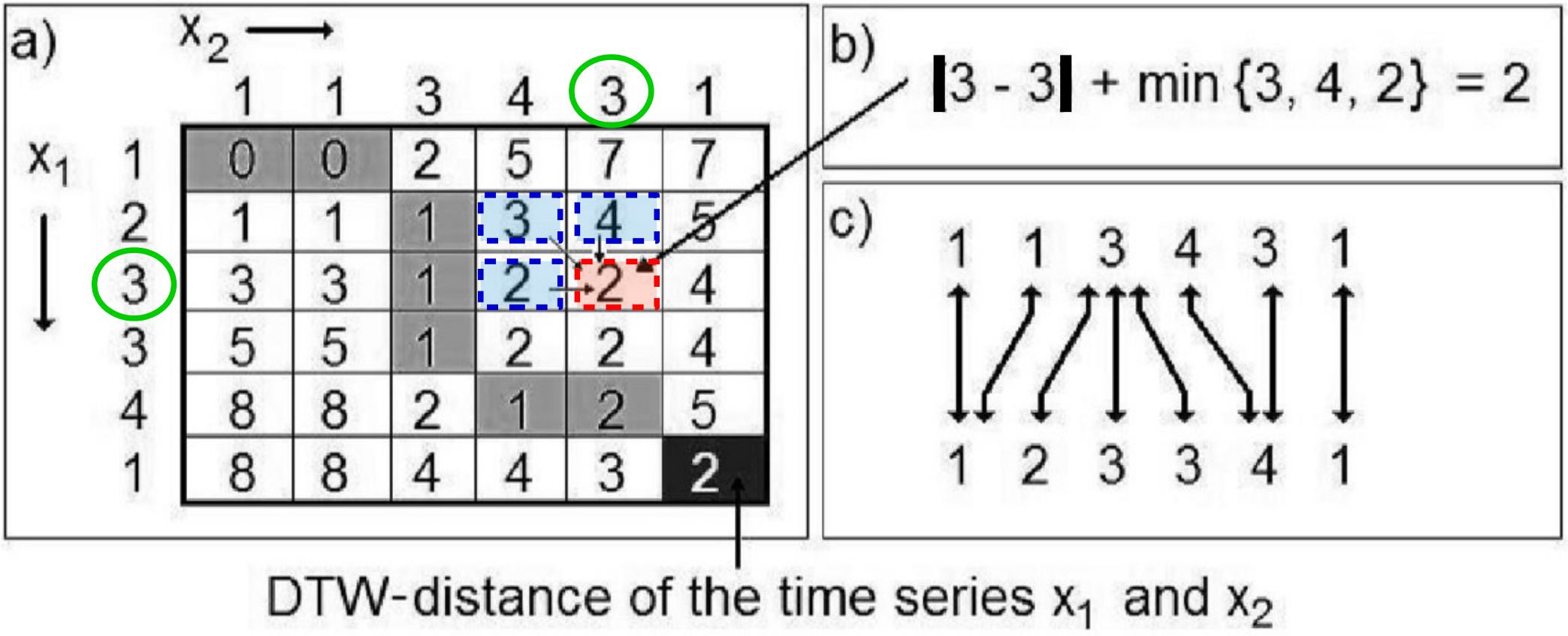
x2

Dynamic Time Warping

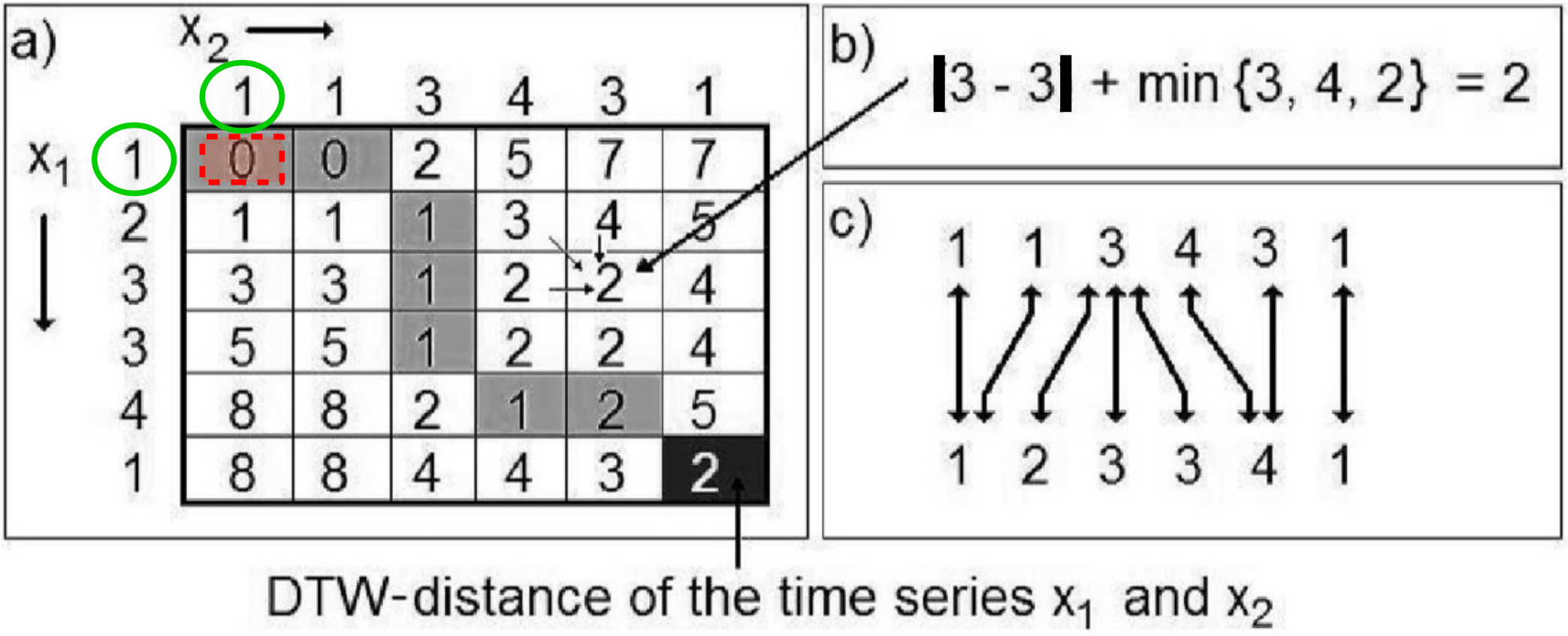




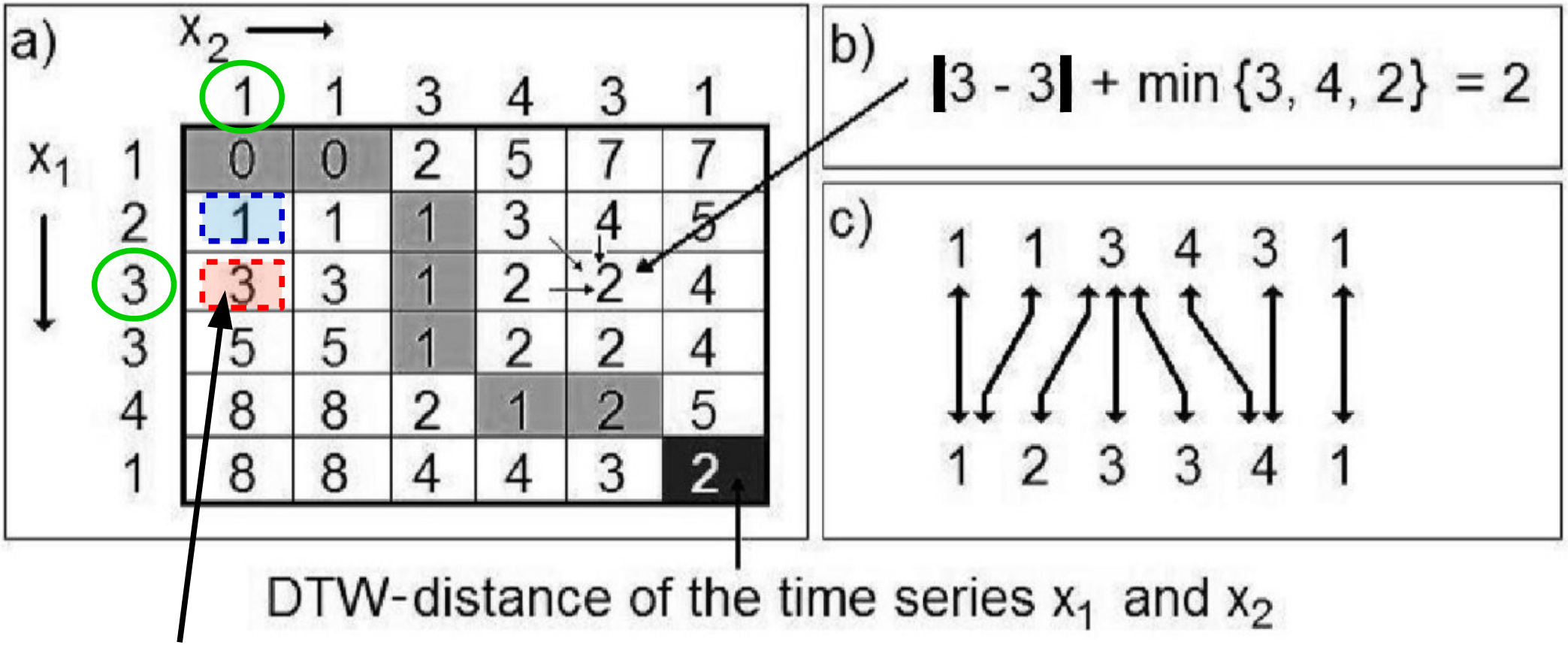
Dynamic Time Warping



Dynamic Time Warping



Dynamic Time Warping



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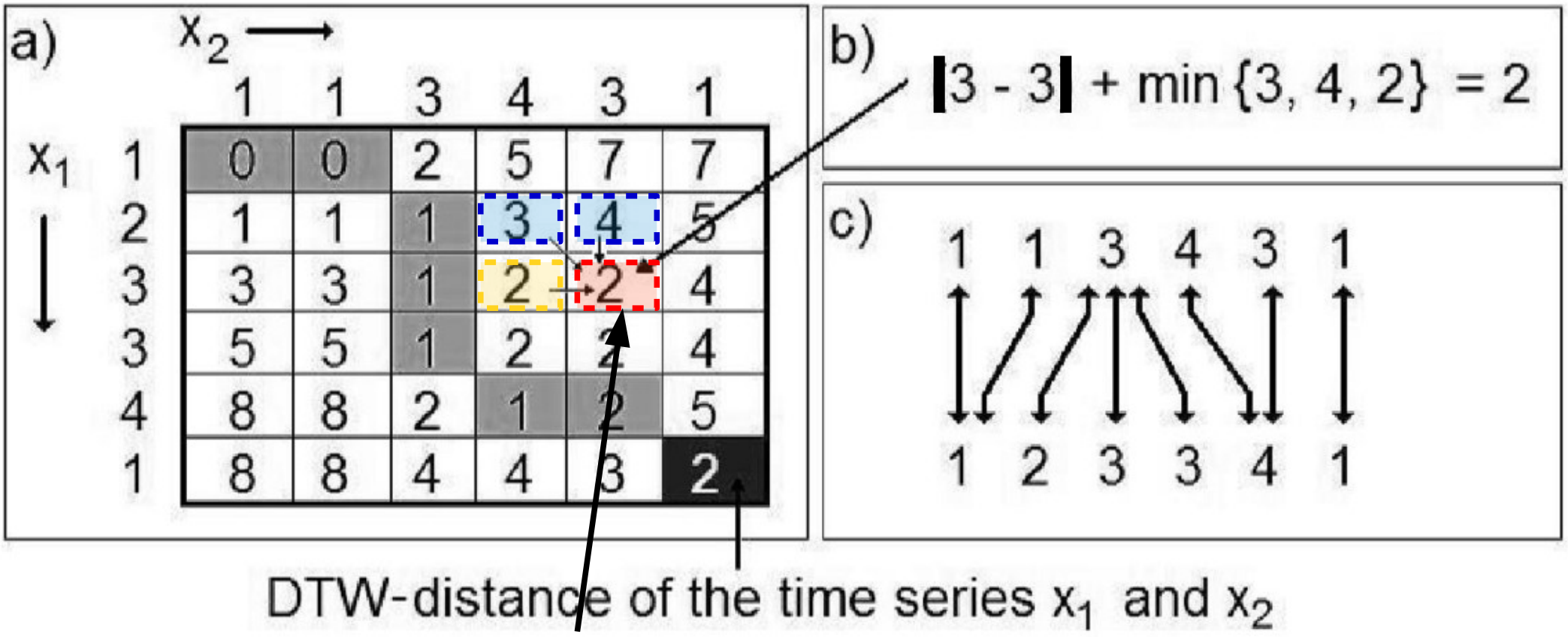

For example, for this entry, we record that the yellow entry had the minimum out of the three entries that were considered while filling-in this entry.