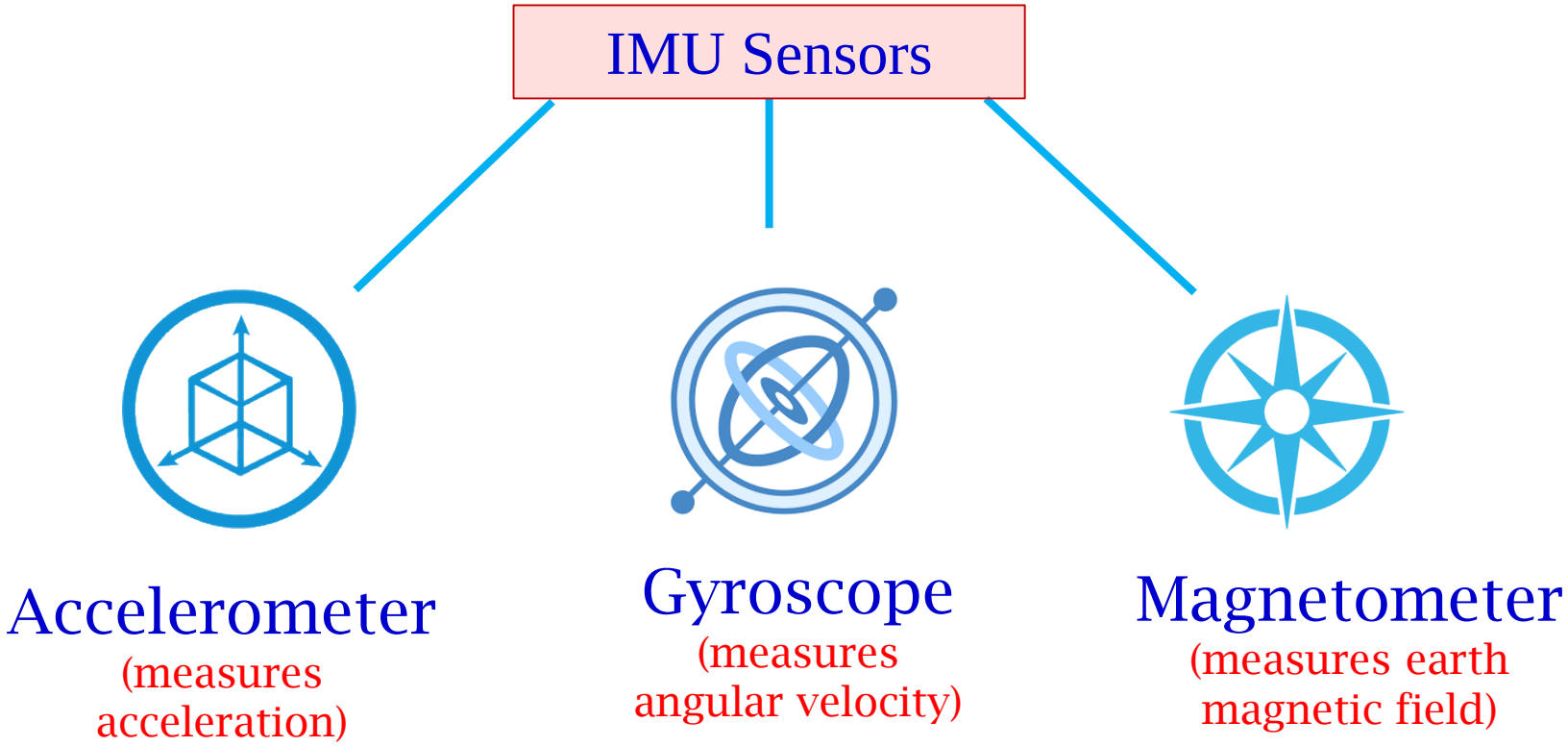
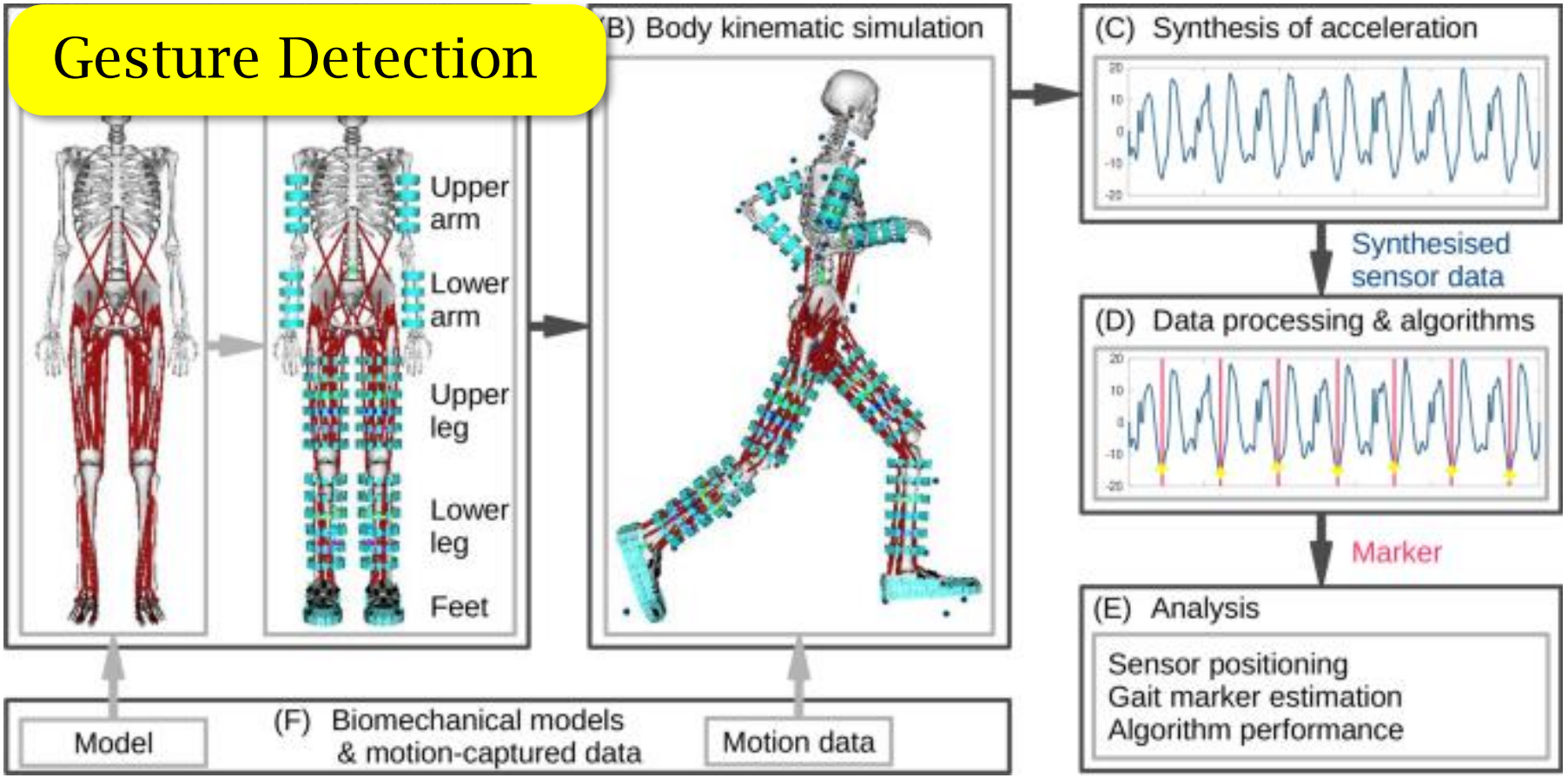
Gesture Recognition using IMU sensors

Amitangshu Pal

IMU Sensors

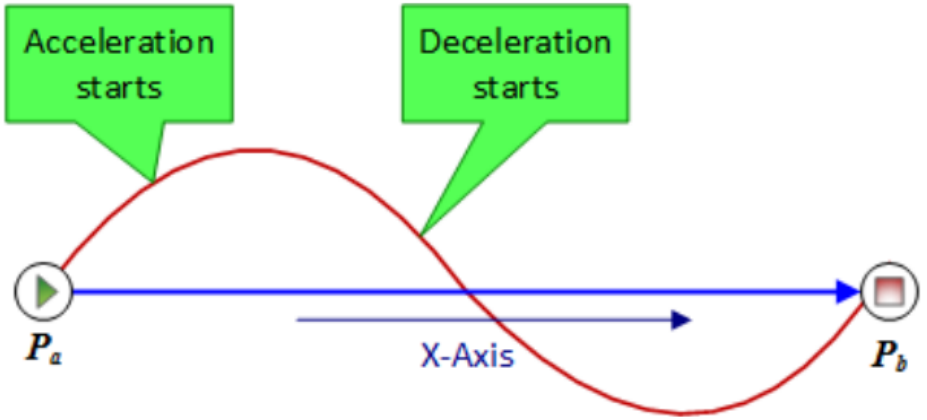

IMU Sensors
Accelerometer
(measures acceleration)
Gyroscope
(measures angular velocity)
Magnetometer
(measures earth magnetic field)

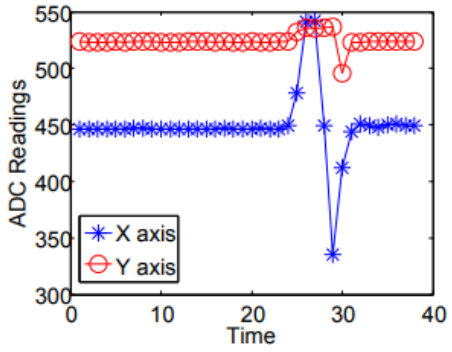
Sensing, Communication and Networking for Smart Wireless Devices

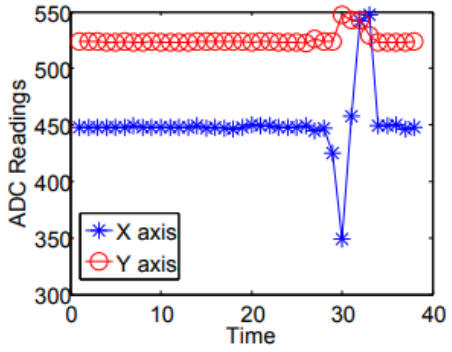


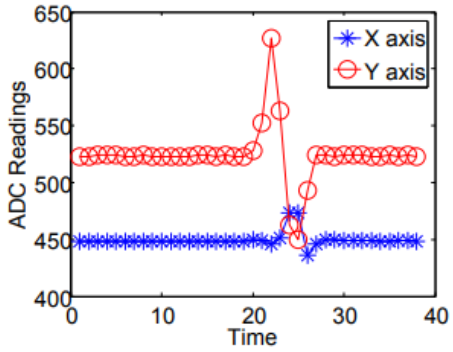
https://www.nature.com/articles/s41598-020-68225-6

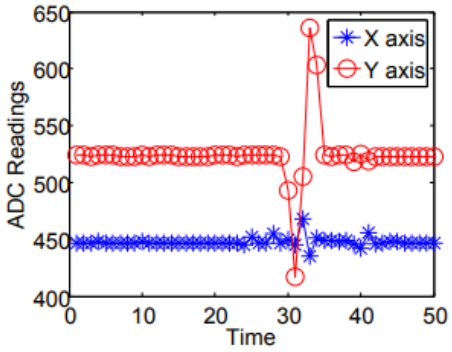
Hand Movement Detection with Strokes



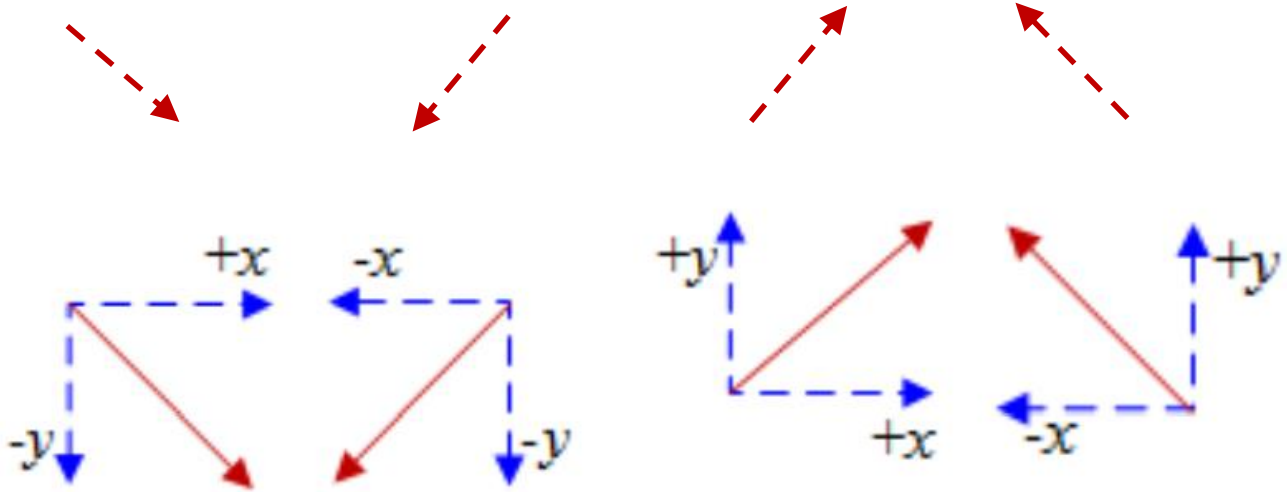


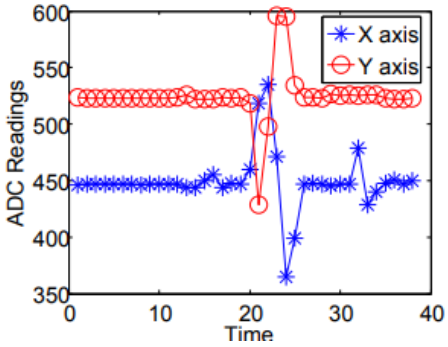


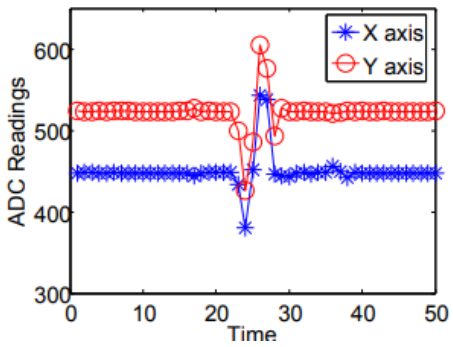


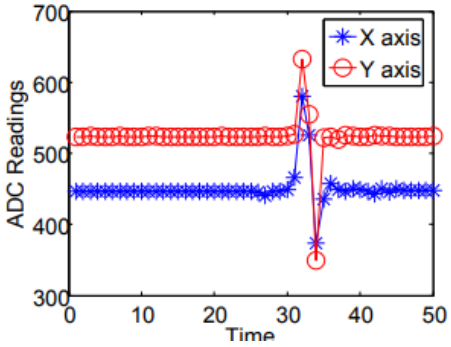


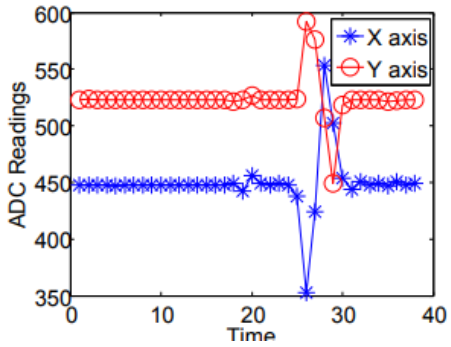
Hand Movement Detection with Strokes



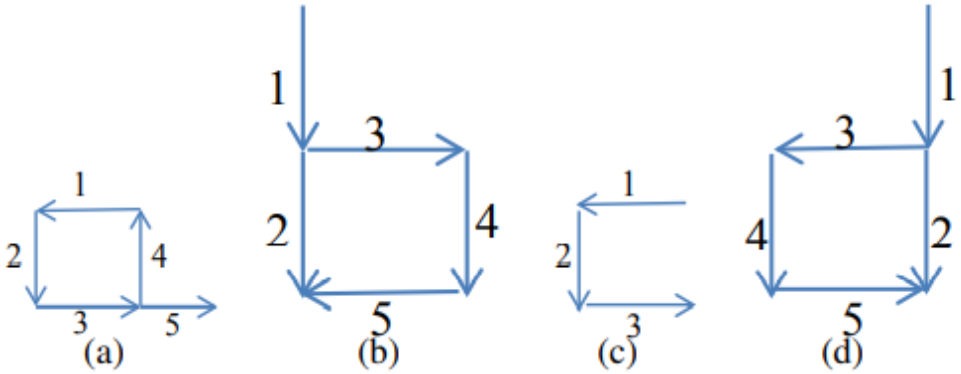


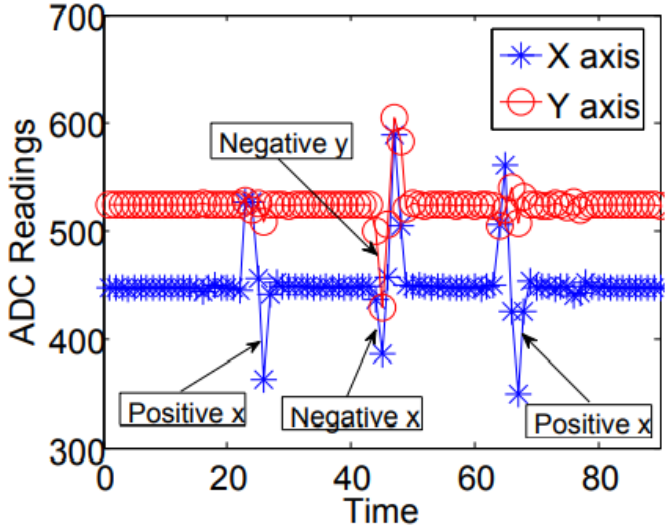




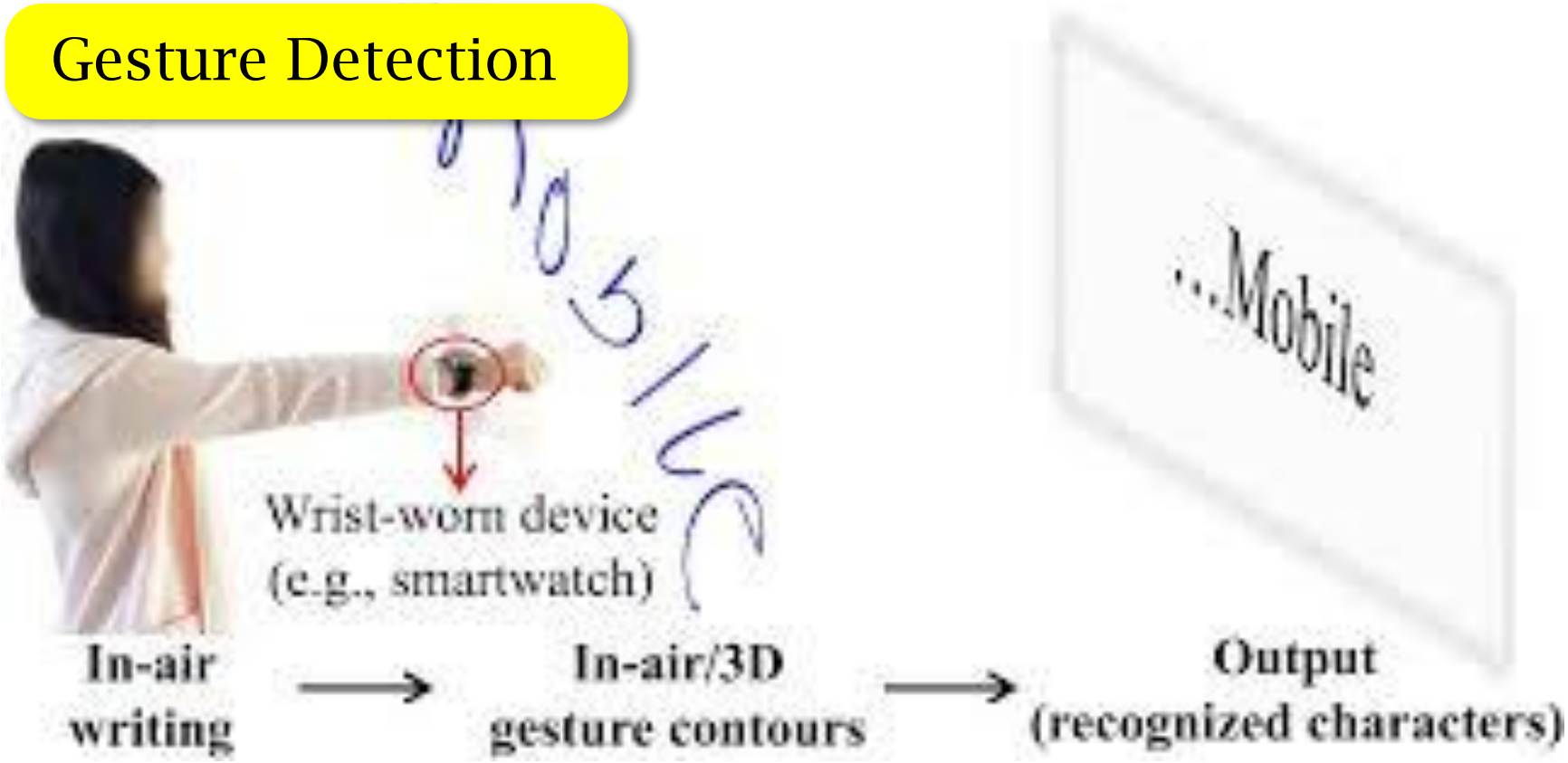


Hand Movement Detection with Strokes





Sensing, Communication and Networking for Smart Wireless Devices



https://www.youtube.com/watch?v=Poi0MeASmuY

Audio Signal Matching

Doors and corners, kid. That's where they get you.

Doors and corners, kid. That's where they get you.

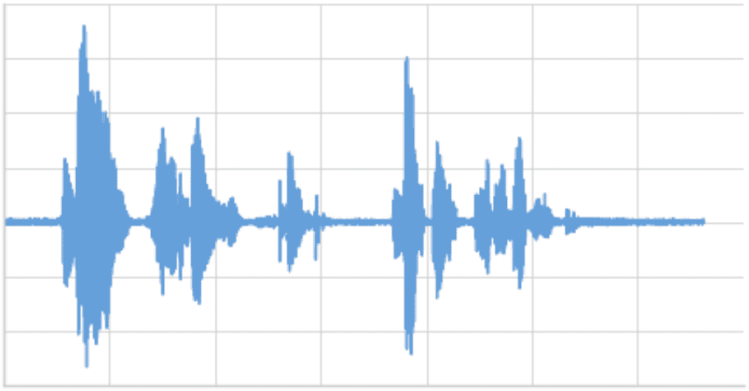
You walk into a room too fast, the room eats you.

Doors and corners, kid. That's where they get you.

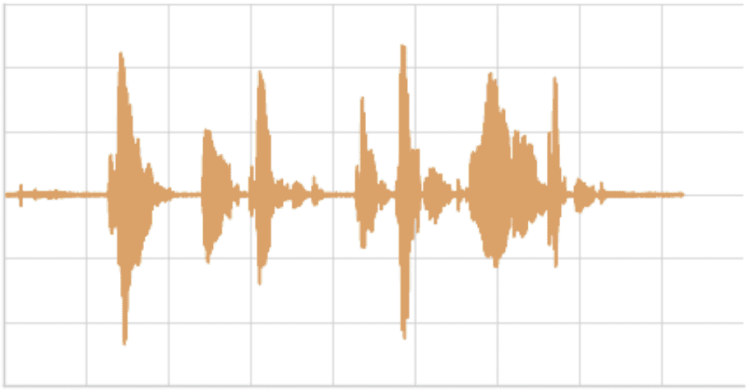
https://databricks.com/blog/2019/04/30/understanding-dynamic-time-warping.html

Audio Signal Matching

Doors and Corners, Kid. That's where they get you.



Doors and Corners, Kid. That's where they get you.(v2)



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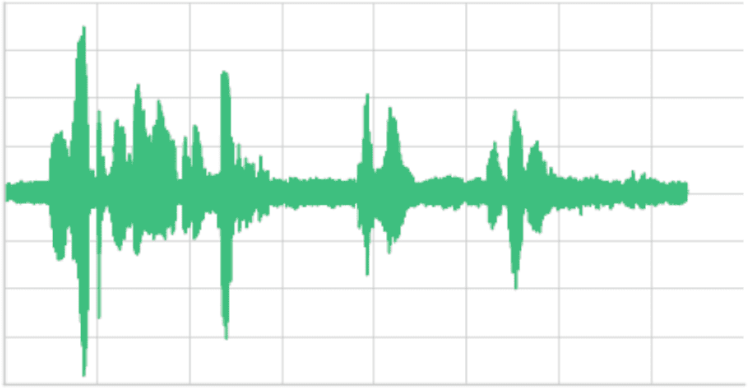
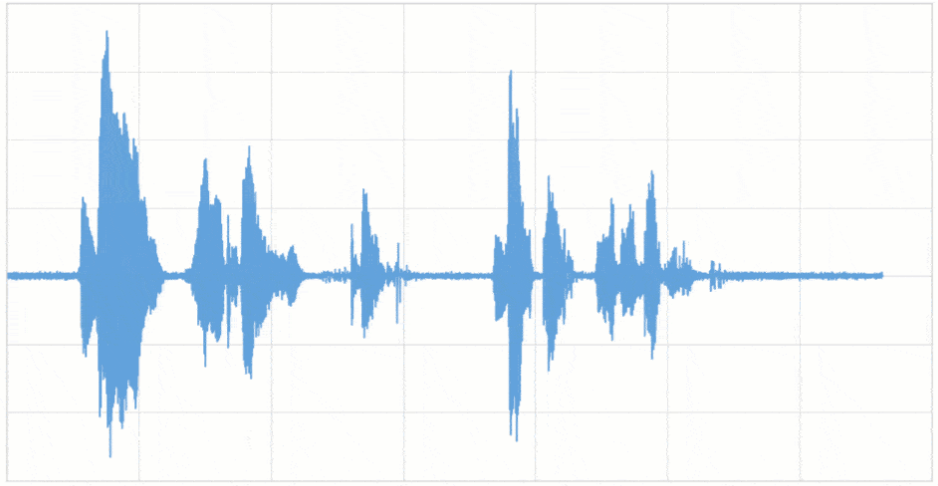


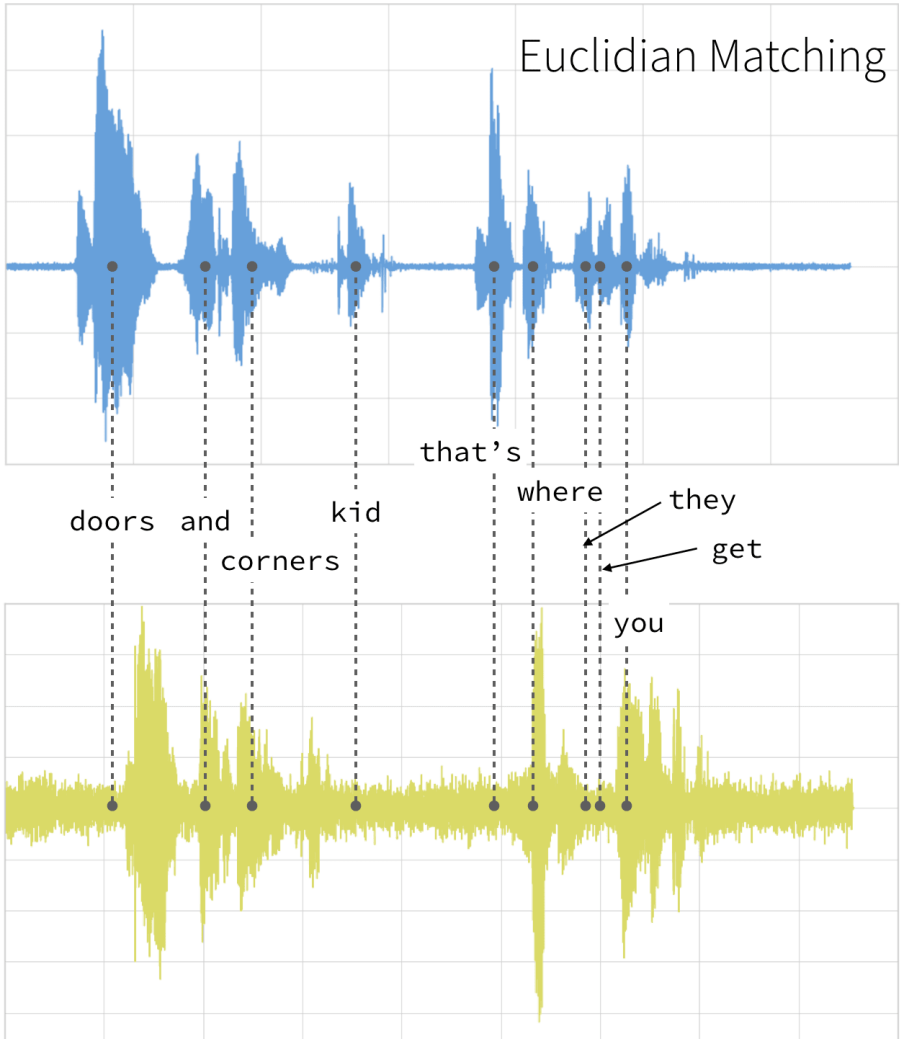
Doors and Corners, Kid. That's where they get you.(v3)

Audio Signal Matching

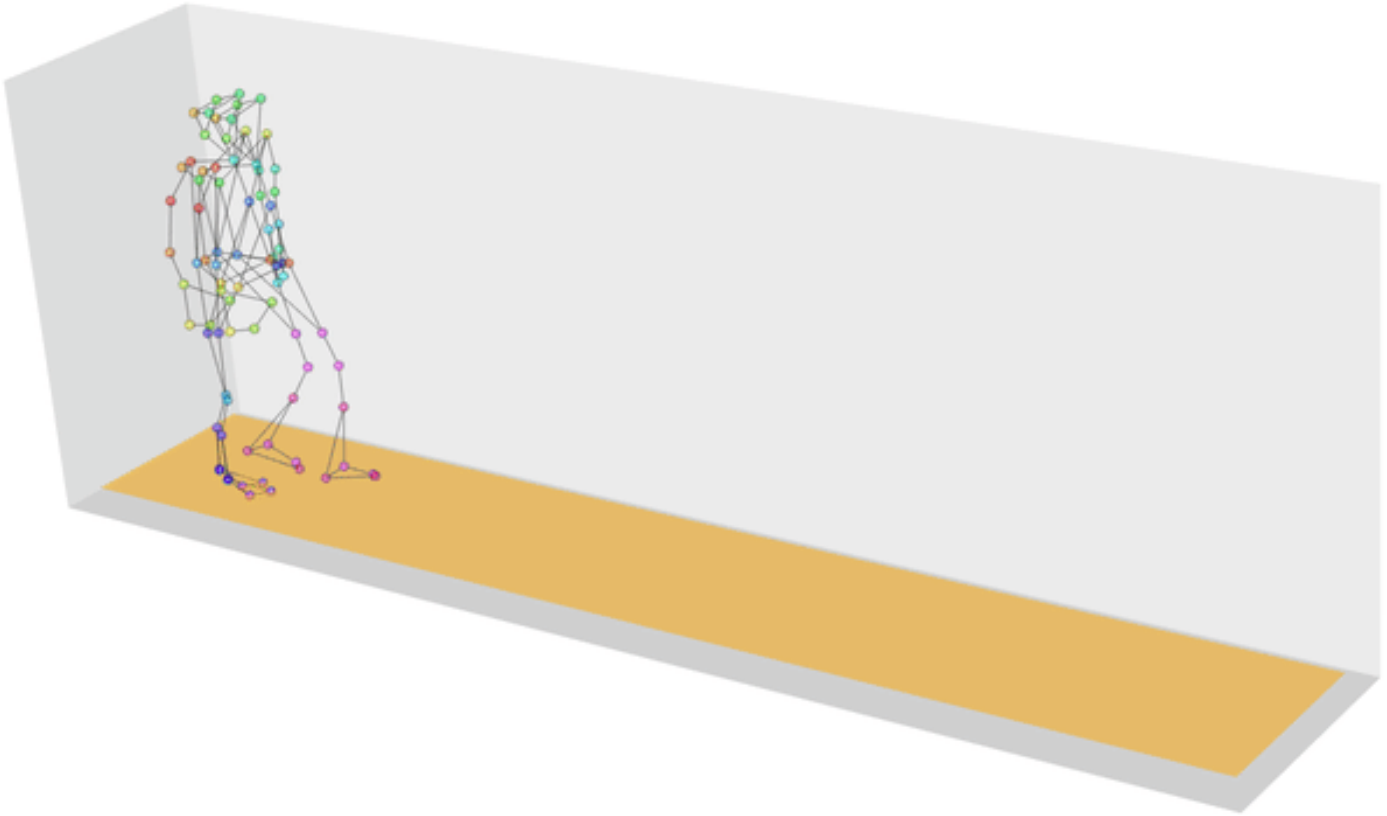


Doors and corners, kid. That's where they get you.

Calculating Euclidian Distance is not Sufficient



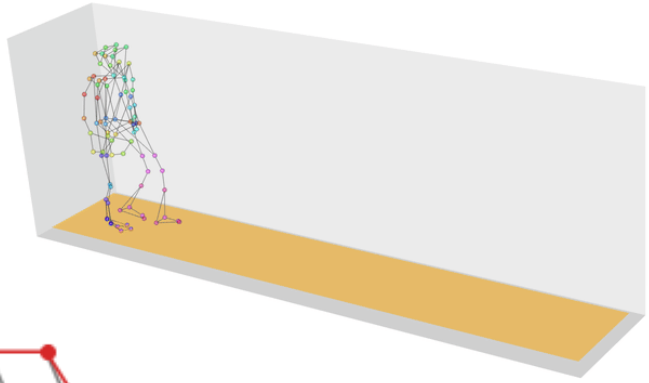
Walking Pattern Matching

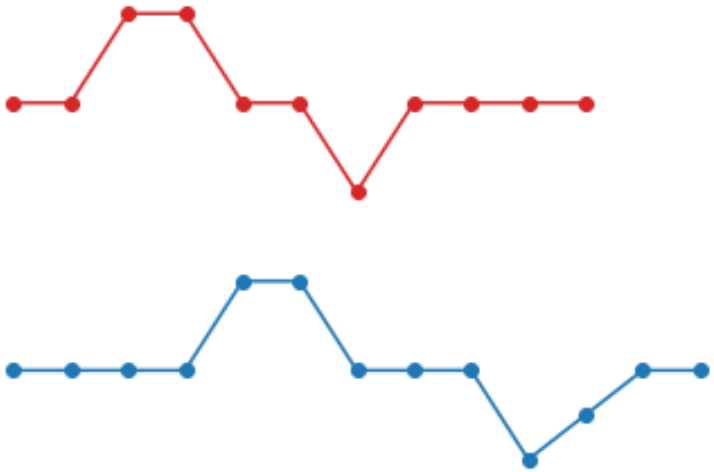


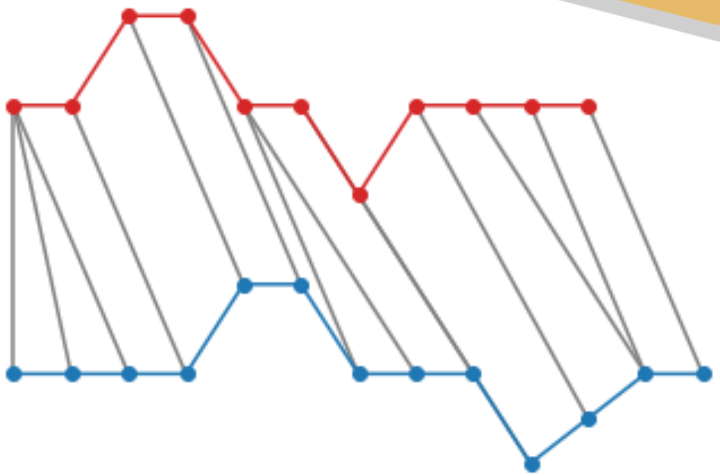
https://en.wikipedia.org/wiki/File:Two_repetitions_of_a_walking_sequence_of_an_individual_recorded_using_a_motion-capture_system.gif

Dynamic Time Warping

- How similar are two signals?
- Which points corresponding to one another?





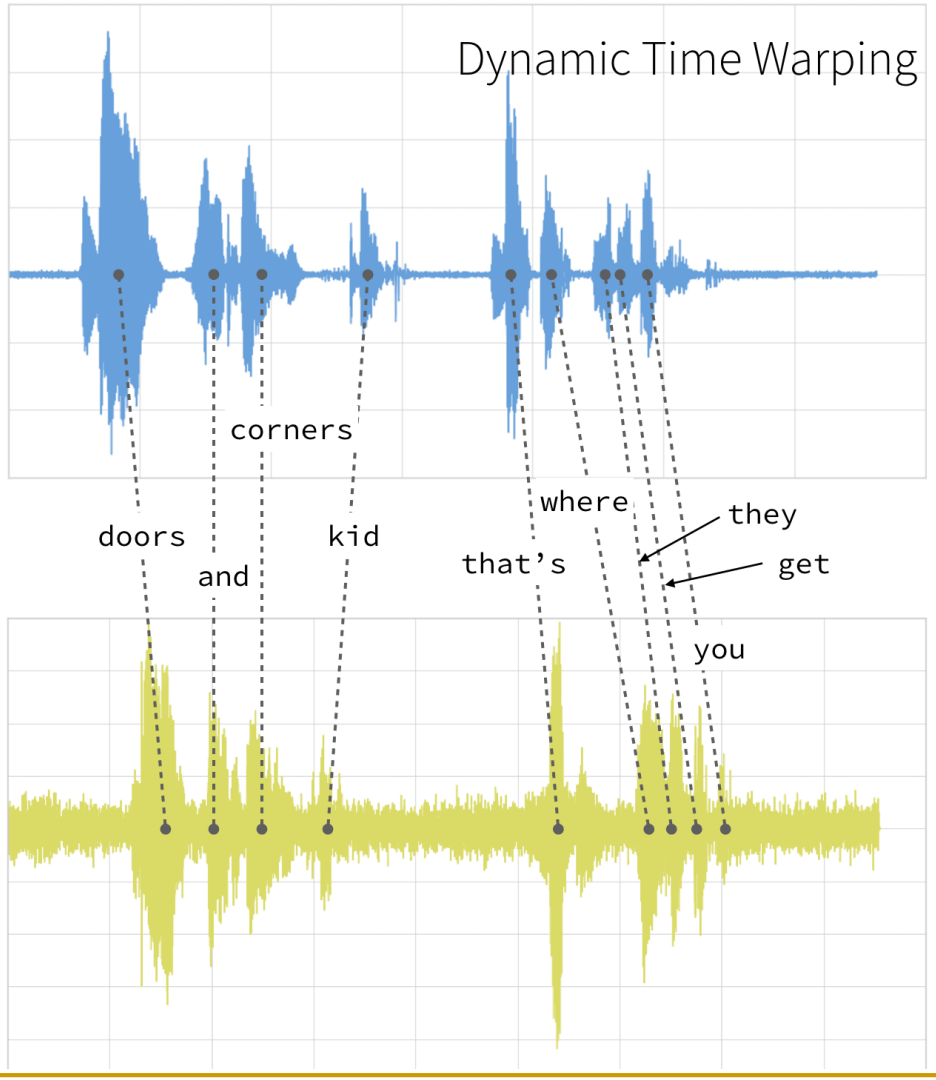


ED: Produces poor similarity score

DTW: More intuitive similarity score → allows similar shapes to match even if they are out of phase

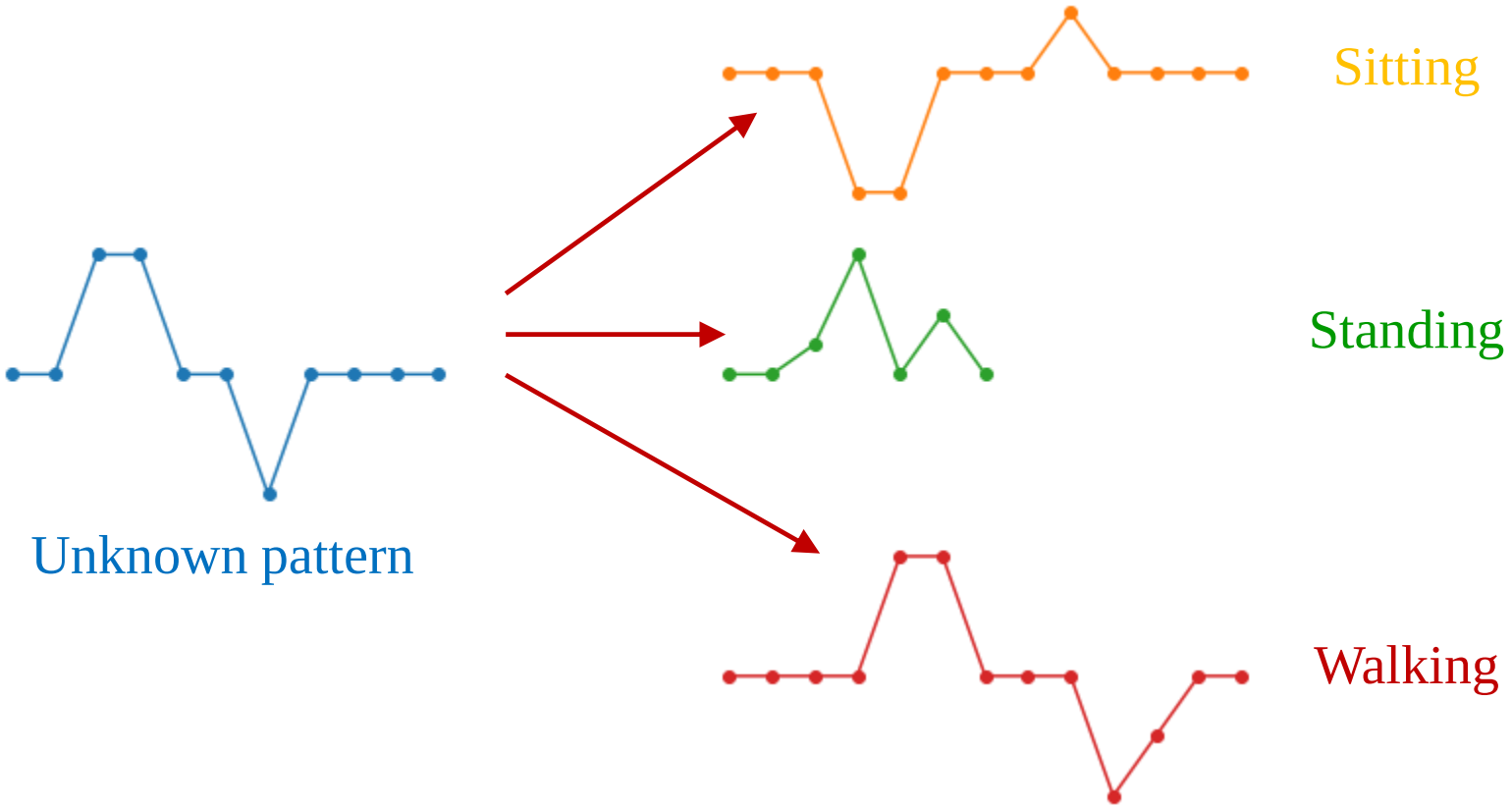
Src: Herman Kamper, 2021. Licensed under CC BY-SA 4.0

DTW for Audio Signal Matching



DTW for Posture Detection

- How similar are two signals?
- Which points corresponding to one another?



Systematic DTW Algorithm

Inputs: $x_{1:N}$ and $y_{1:M}$

Cost matrix: $D \in \mathbb{R}^{N+1 \times M+1}$

Initialization: for $i = 1$ to N: $D_{i,0} = \infty$

for $j = 1$ to M: $D_{0,j} = \infty$

$D_{0,0} = 0$

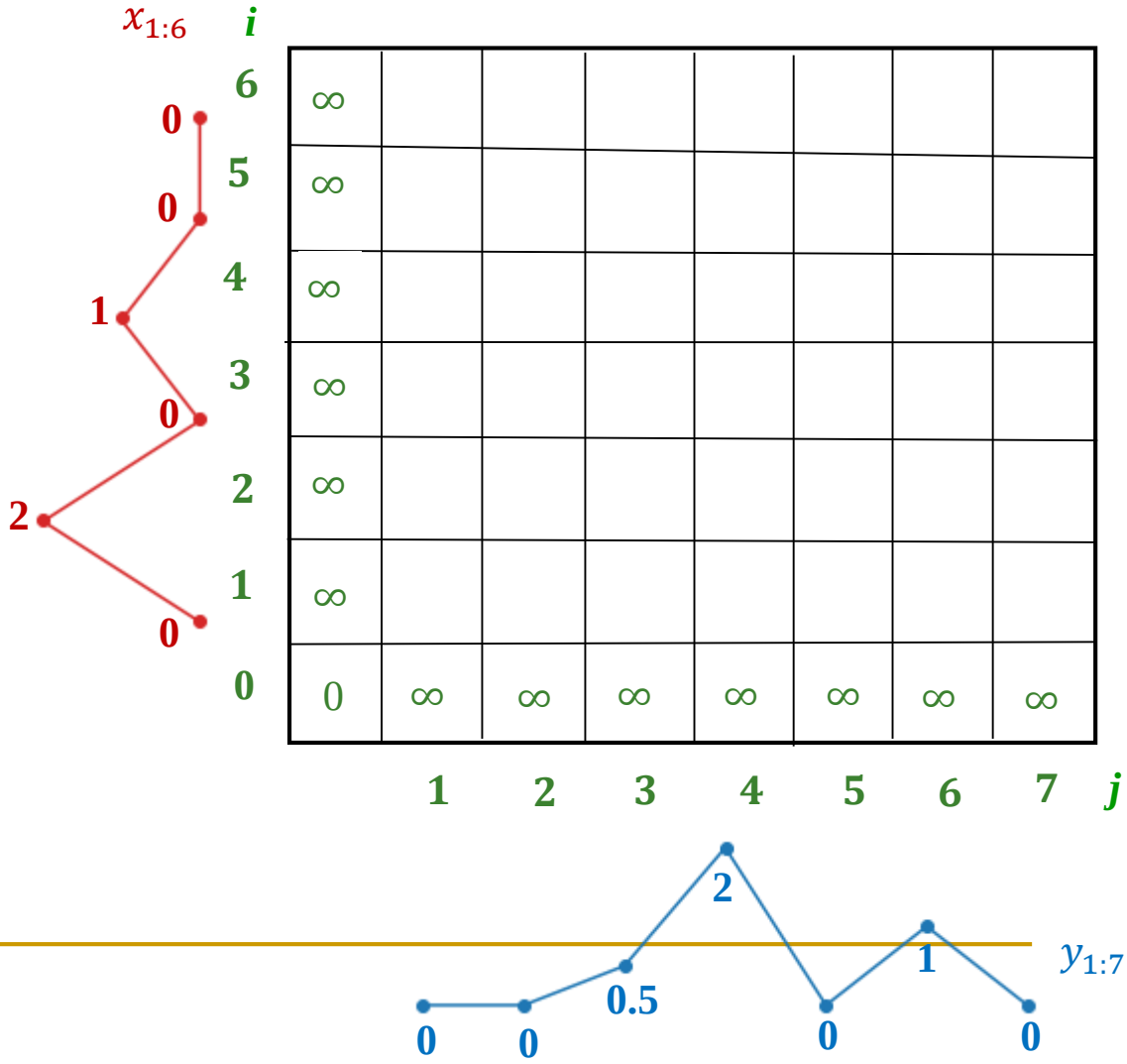
Calculate cost matrix:

for $i = 1$ to N:

for $j = 1$ to M:

$$D_{ij} = d(x_i, y_j) + \min \begin{bmatrix} D_{i-1,j-1} \\ D_{i-1,j} \\ D_{i,j-1} \end{bmatrix}$$

Get alignment: Trace back from $D_{N,M}$ to $D_{0,0}$



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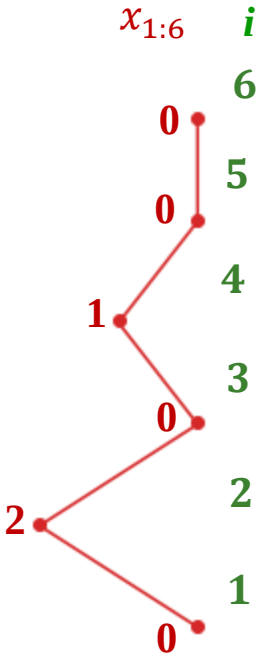
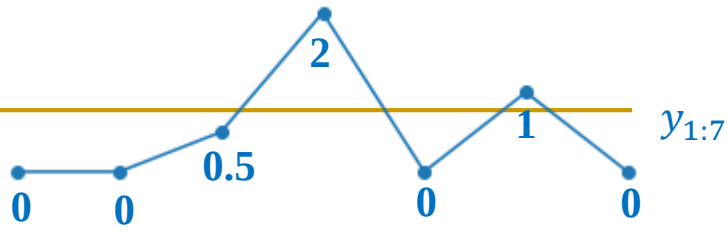


∞	3	3	3.5	5	1.5	2.5	0.5
∞	3	3	3	4.5	1.5	1.5	0.5
∞	3	3	2.5	3	1.5	0.5	1.5
∞	2	2	2	2.5	0.5	1.5	1.5
∞	2	2	1.5	0.5	2.5	3.5	5.5
∞	0	0	0.5	2.5	2.5	3.5	3.5
0	∞	∞	∞	∞	∞	∞	∞

1 2 3 4 5 6 7 j



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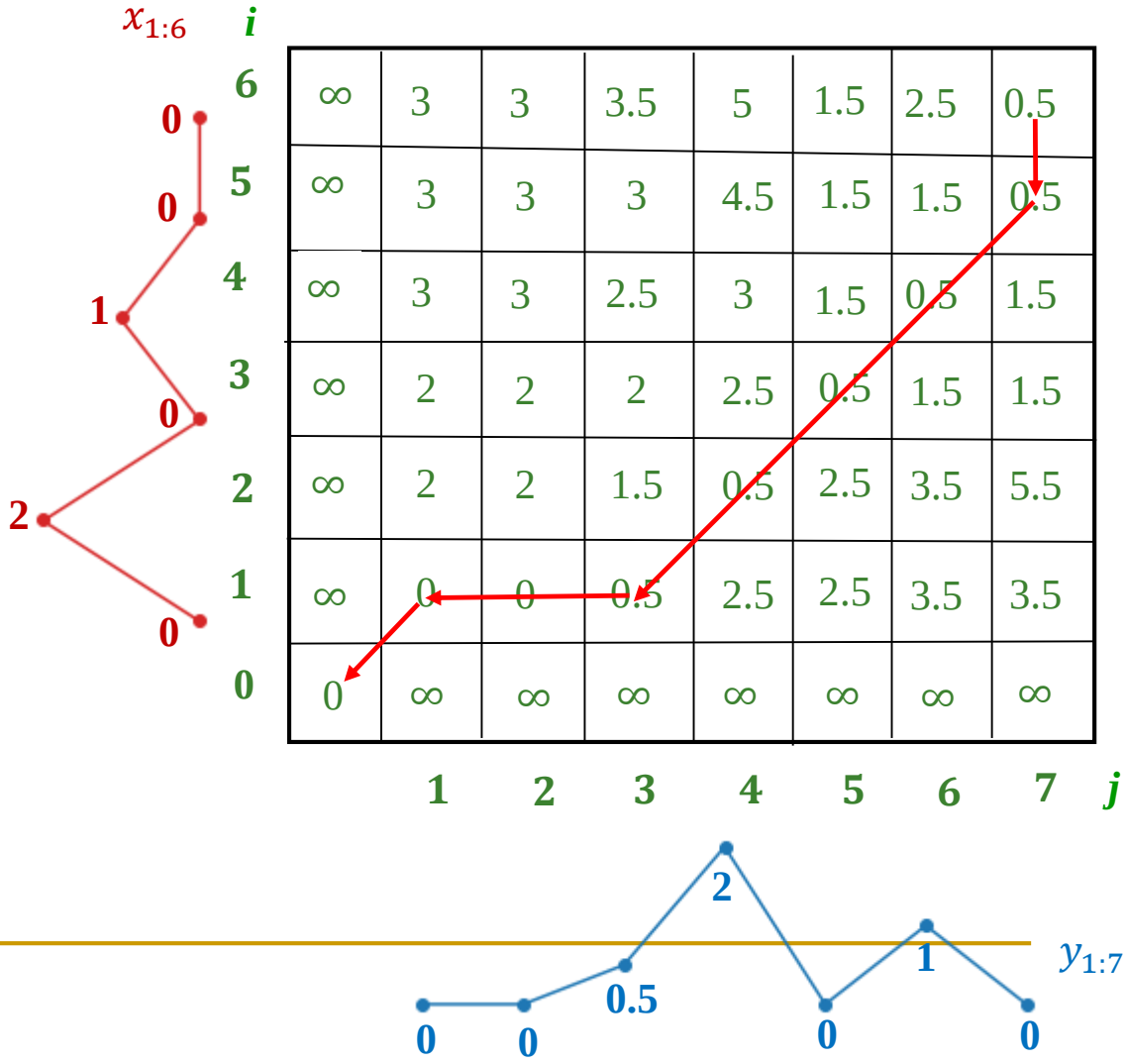
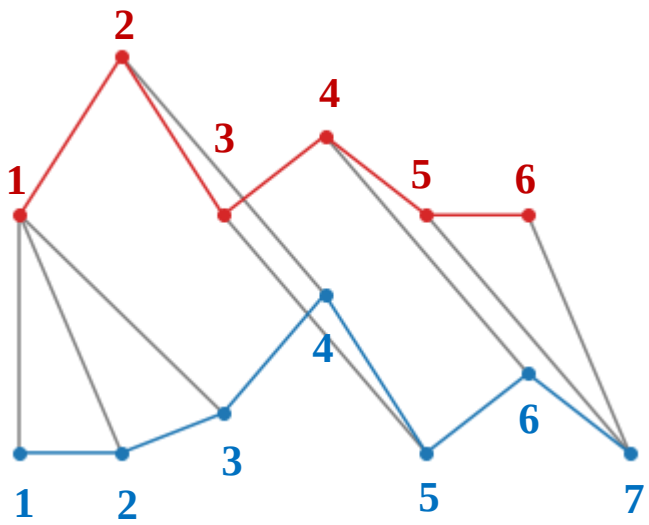
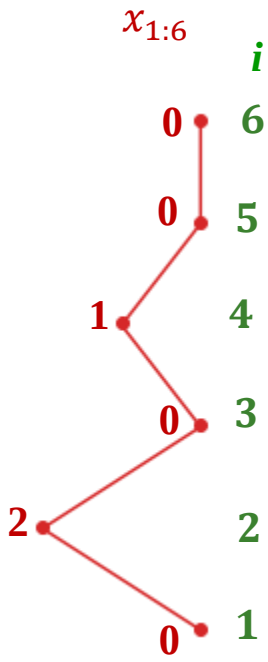


Systematic DTW Algorithm



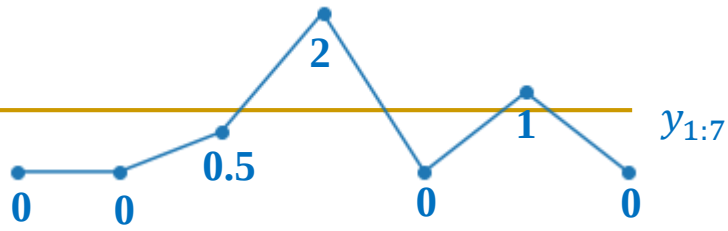


i

6	∞	3	3	3.5	5	1.5	2.5	0.5
5	∞	3	3	3	4.5	1.5	1.5	0.5
4	∞	3	3	2.5	3	1.5	0.5	1.5
3	∞	2	2	2	2.5	0.5	1.5	1.5
2	∞	2	2	1.5	0.5	2.5	3.5	5.5
1	∞	0	0	0.5	2.5	2.5	3.5	3.5
0	0	∞	∞	∞	∞	∞	∞	∞
		1	2	3	4	5	6	7

j

Cost: 0.5



DTW for Audio Signal Matching

Doors and corners, kid. That's where they get you.

Doors and corners, kid. That's where they get you.

Base	Query	Distance
Clip 1	Clip 2	480148446.0
	Clip 3	310038909.0
	Clip 4	293547478.0

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