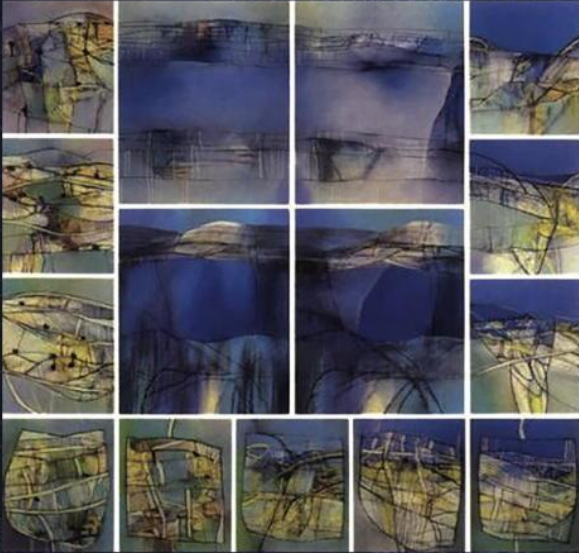


# ARTIFICIAL INTELLIGENCE

Humans at the Heart of Algorithms

*Second Edition*



Alan Dix

A Chapman & Hall Book

 CRC Press  
Taylor & Francis Group

## Chapter 14

# Time Series and Sequential Data

# Stock market leading up to and after Black Monday

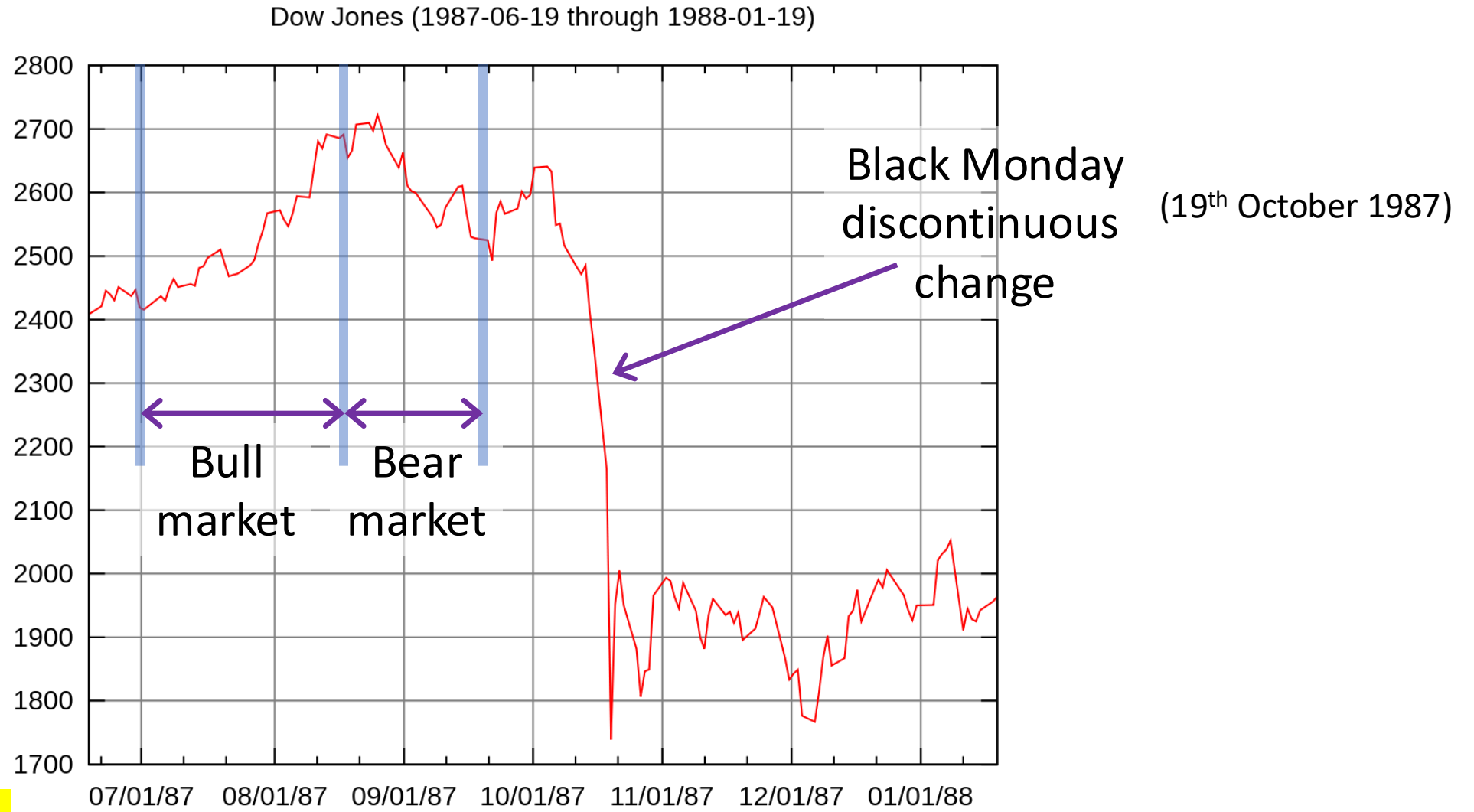


Fig. 14.1

Digitally produced spectrogram of a male voice saying  
'nineteenth century'

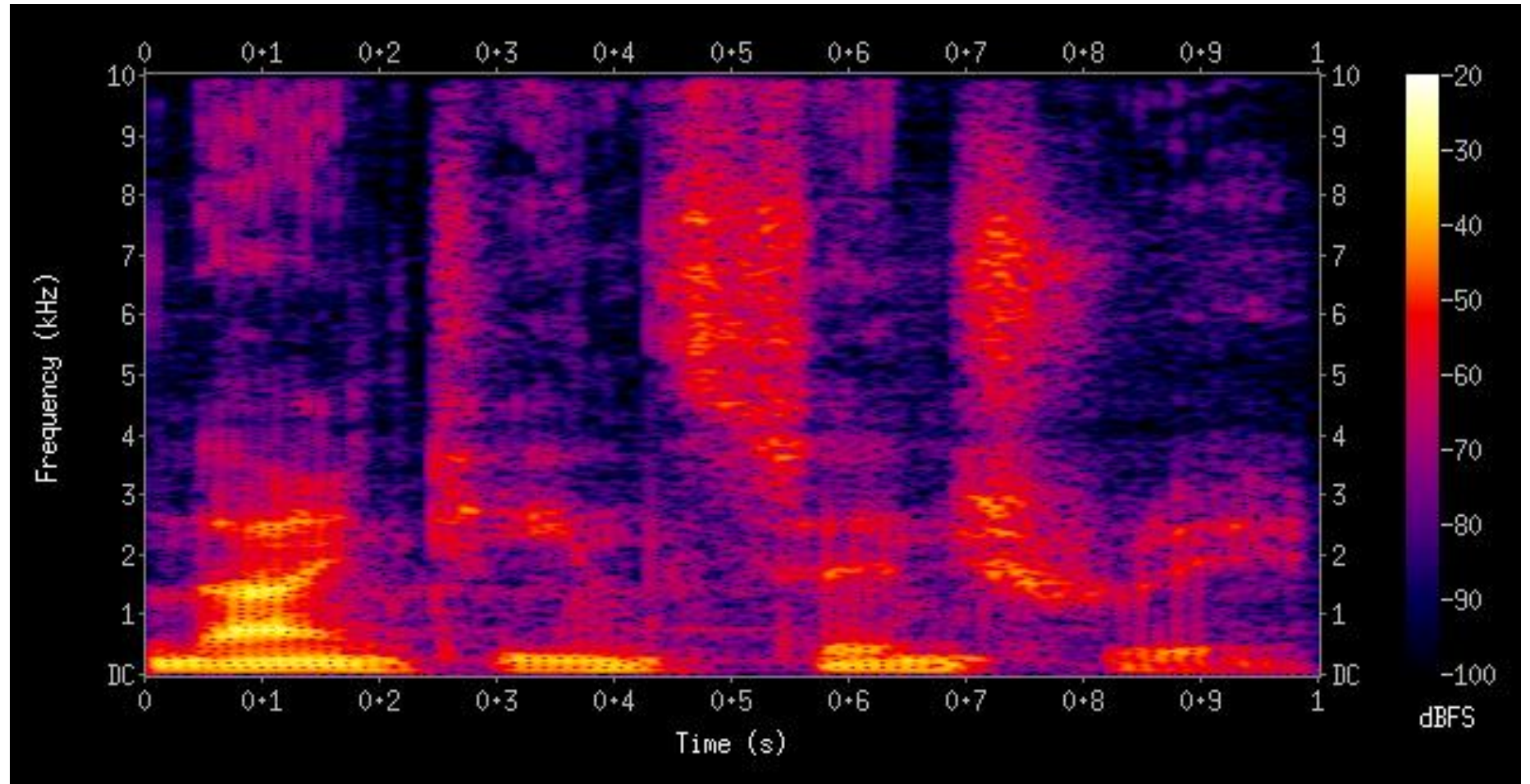
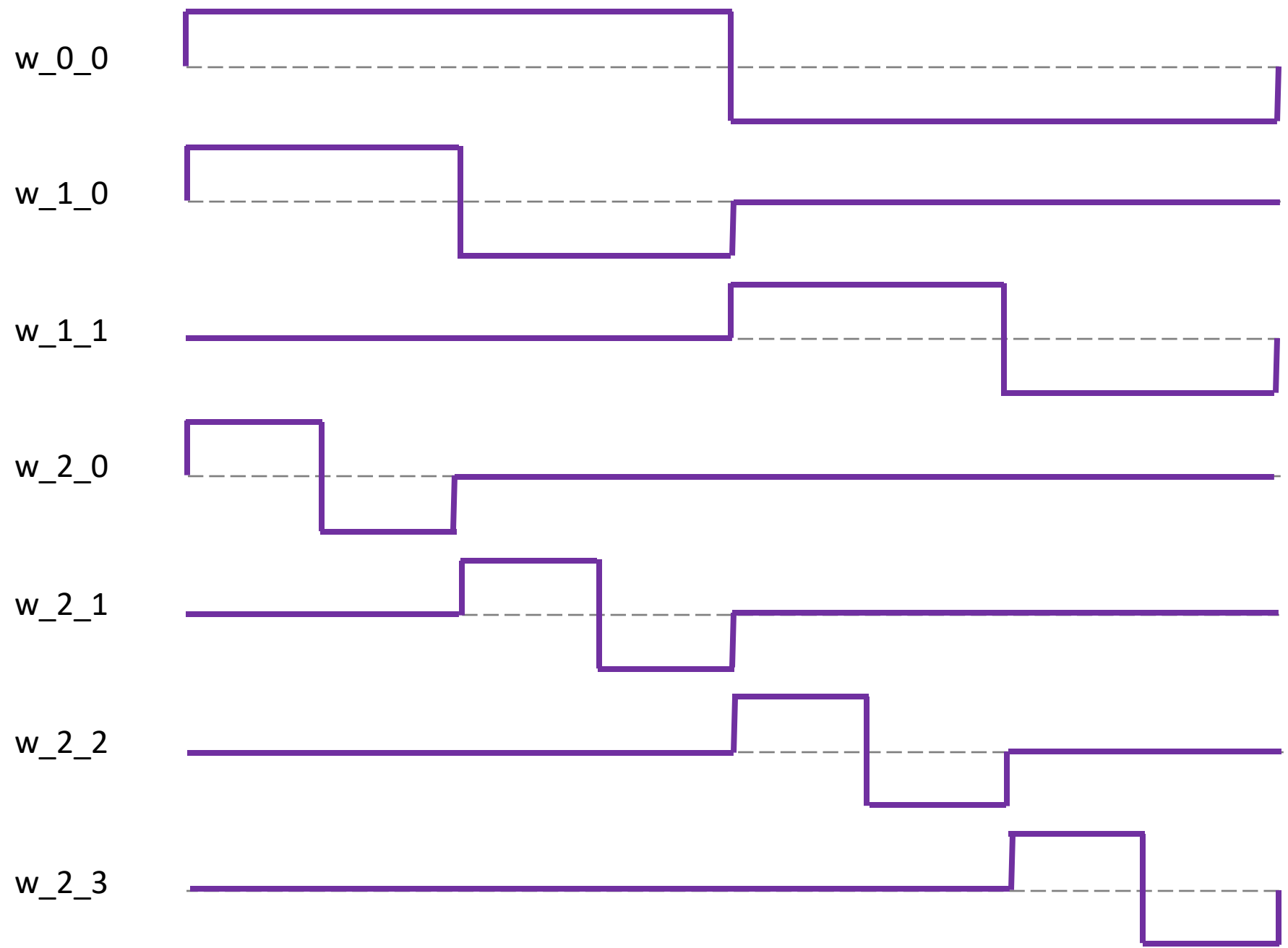


Fig. 14.2

# Haar Wavelet



**Fig. 14.3**

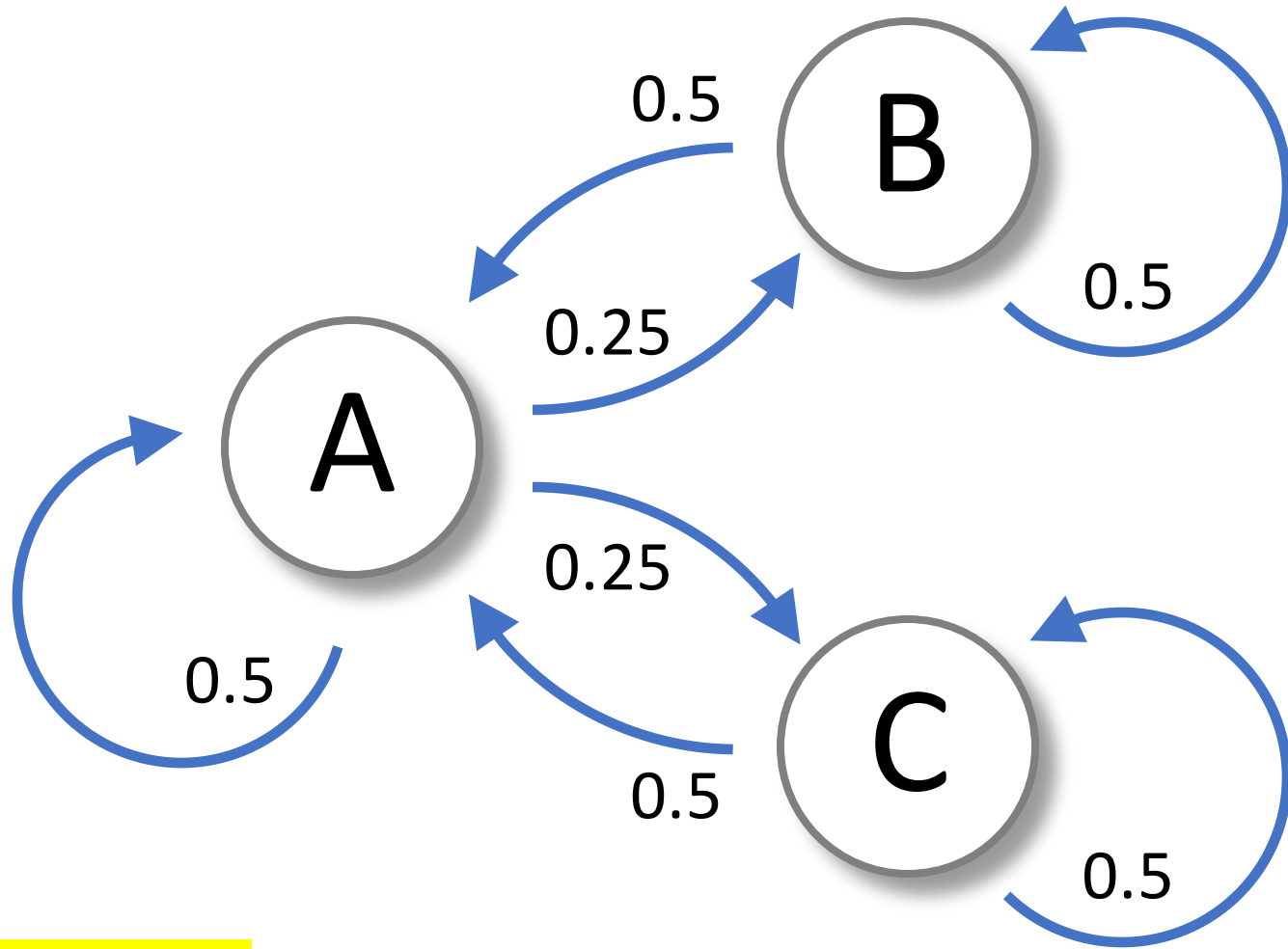
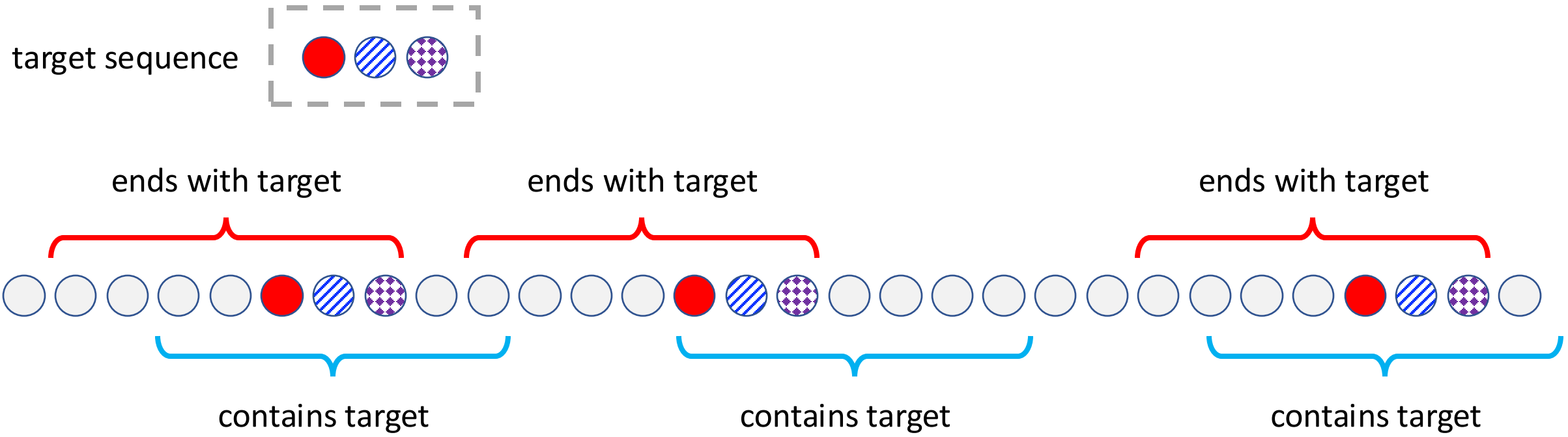


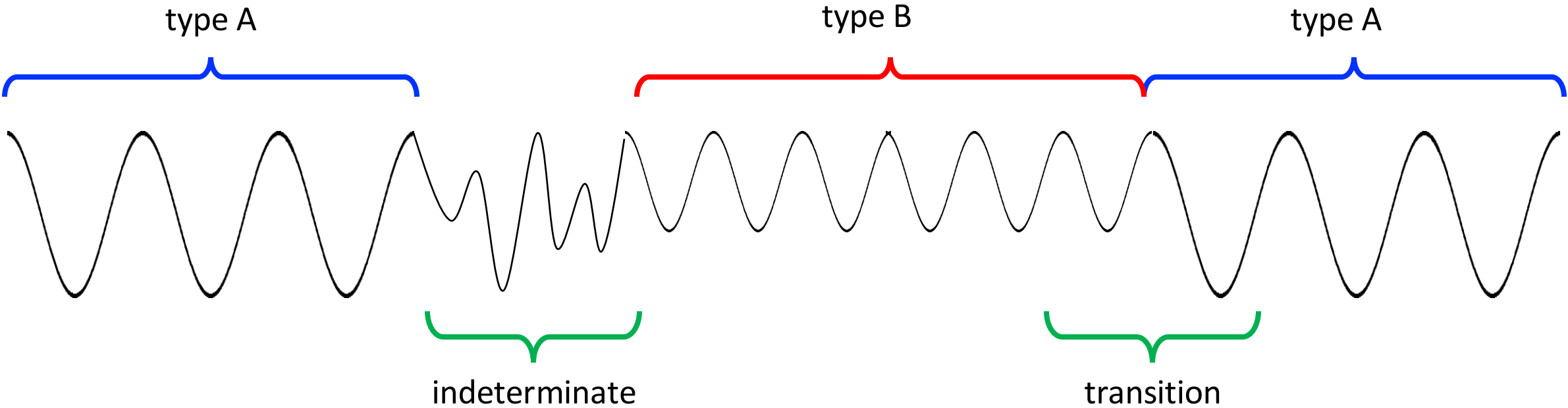
Table 14.1b

# Locating sub-sequences in longer sequence



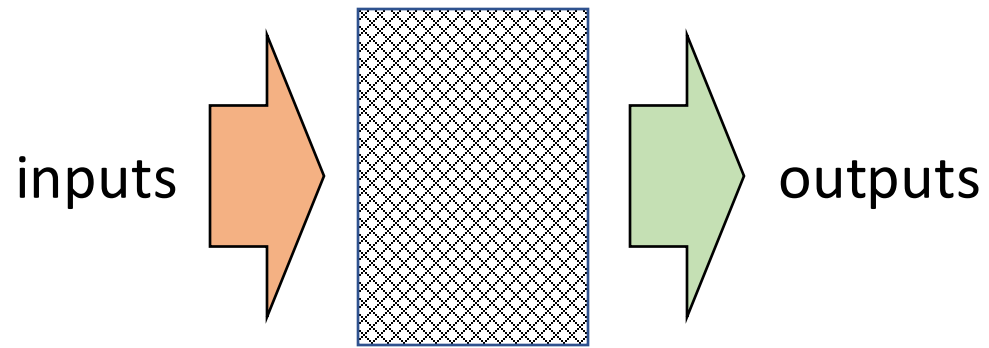
**Fig. 14.4**

# Diffuse classification of regions

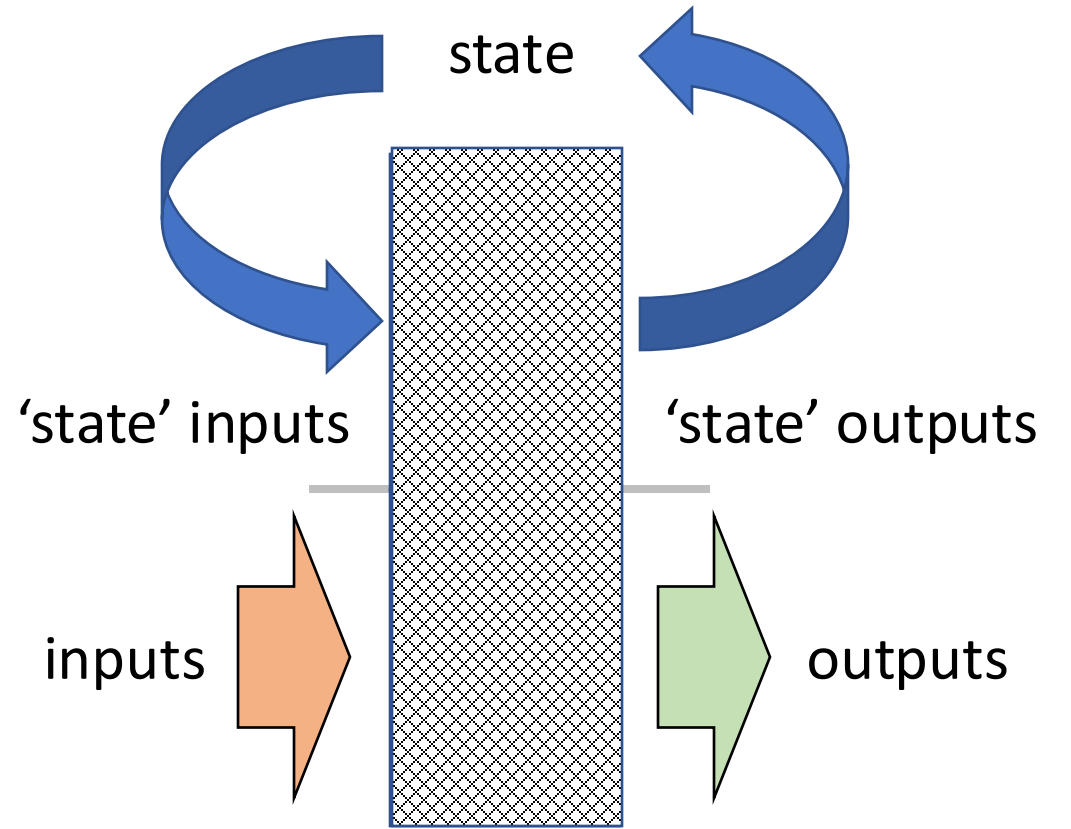


**Fig. 14.5**

# Recurrent neural network (RNN)



(i) standard neural network



(ii) recurrent neural network

**Fig. 14.6**



# Running a recurrent neural network on data stream

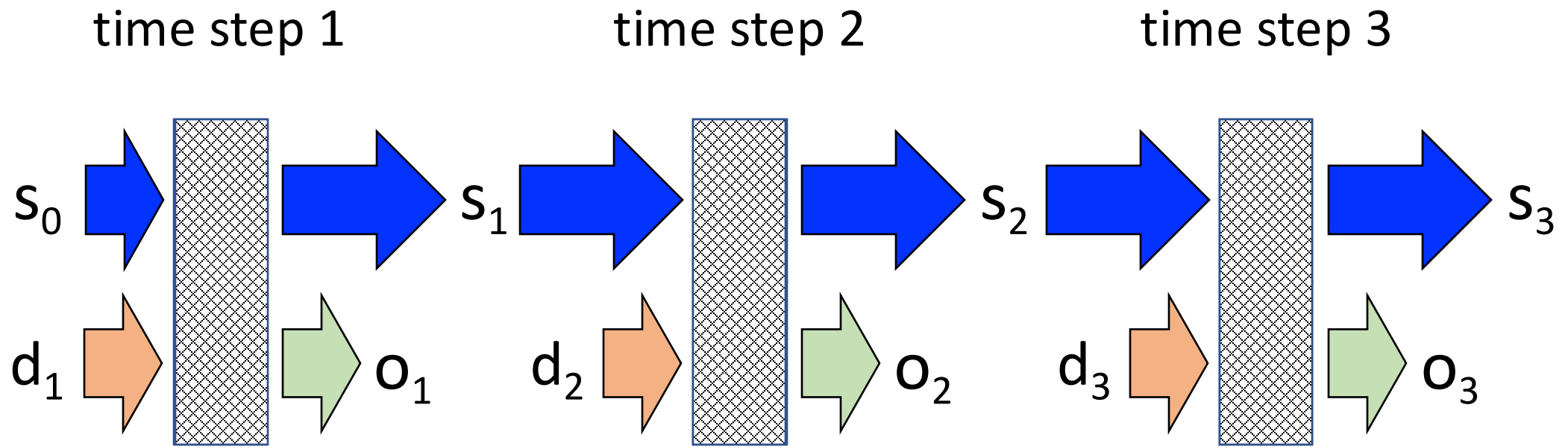
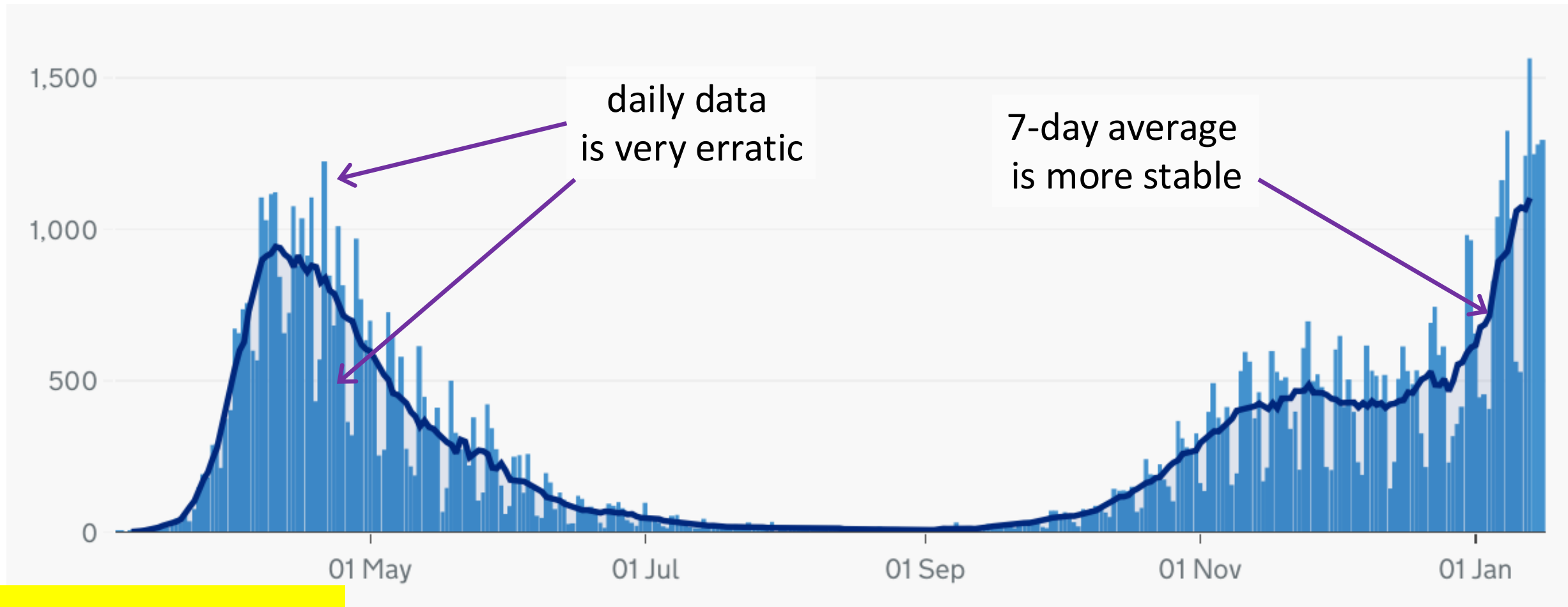


Fig. 14.7

# Covid-19 deaths for UK in 2020



**Fig. 14.8**

# Using statistical processing as pre-processor for other AI techniques

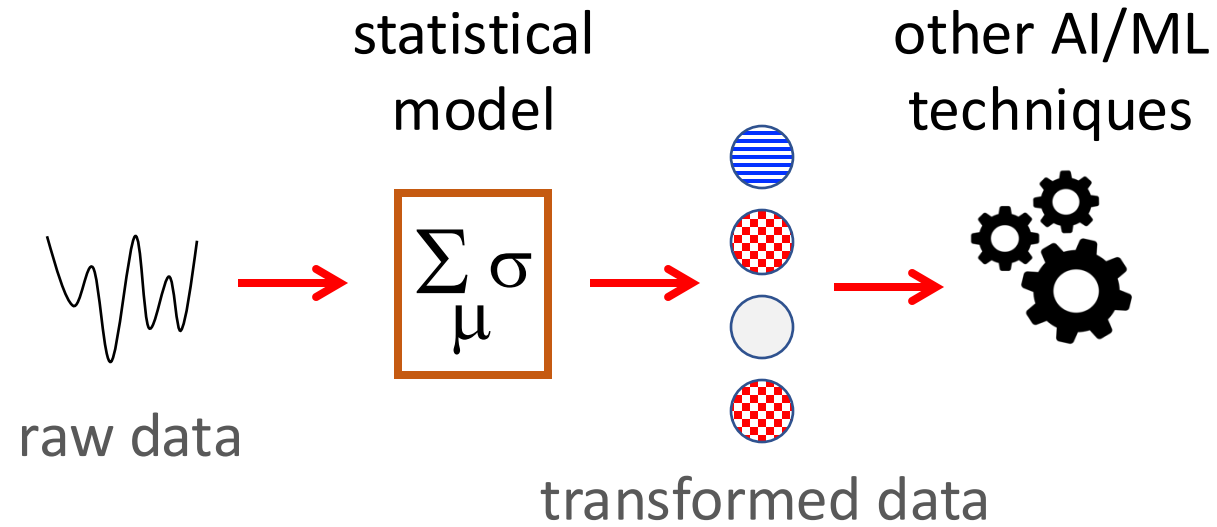


Fig. 14.9

# Using ML to choose parameters for statistical processing

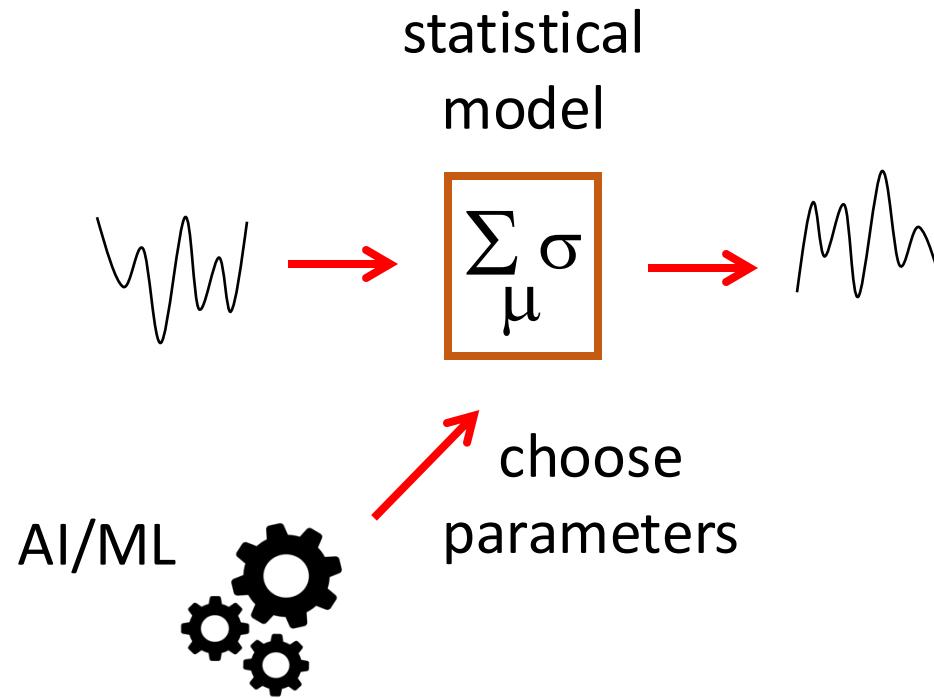
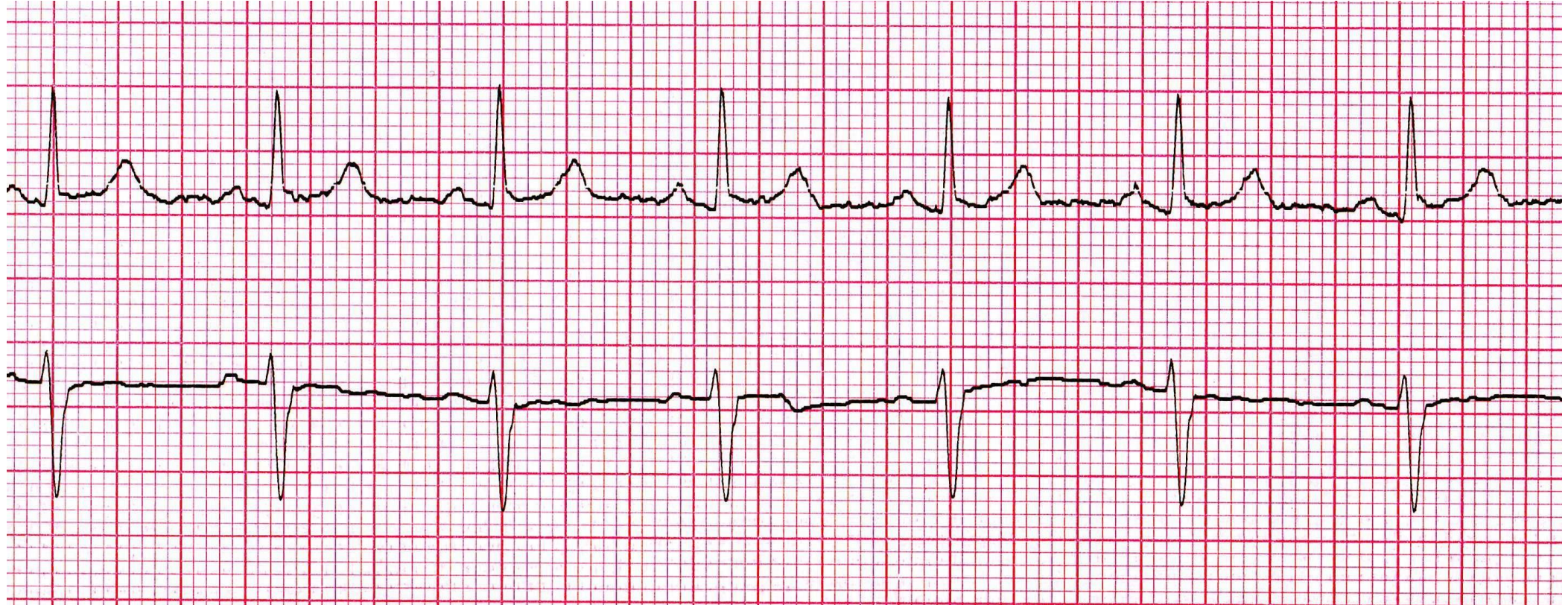


Fig. 14.10

# Extract of ECG trace



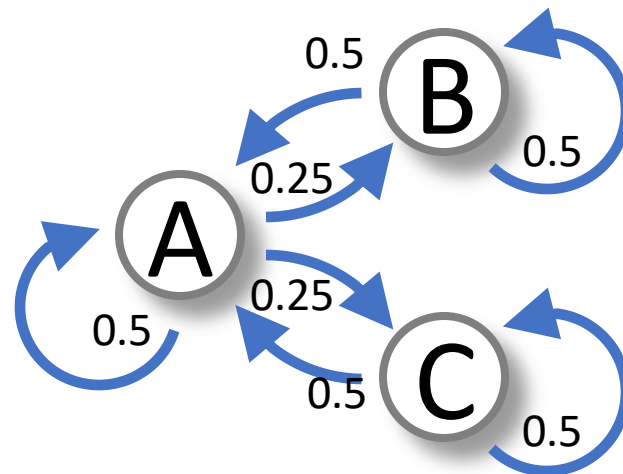
**Fig. 14.11**

Table 14.1 Markov Model (upper)  
Transition Probability Table; (lower)  
Drawn as a Network.

---

Current letter	Next letter		
	A	B	C
A	0.5	0.25	0.25
B	0.5	0.5	0
C	0.5	0	0.5

---



# inline table Section 14.3.1 p.208

---

Raw frequencies			Totals
AA: 7	AB: 3	AC: 9	start with A: 19
BA: 2	BB: 2	BC: 0	start with B: 4
CA: 9	CB: 0	CC: 5	start with C: 14

---

# Table 14.2 Estimated Transition Probabilities Based on Observed Transition Frequencies.

---

Current letter	Next letter		
	A	B	C
A	0.368	0.158	0.474
B	0.500	0.500	0.000
C	0.643	0.000	0.357

---



# Table 14.3 Markov Model Transition Probability Based on Previous Two Letters.

Last 2 letters	Next letter	
	A	B
AA	0.75	0.25
AB	0.5	0.5
BA	0.25	0.75
BB	1	0

# inline table Section 14.3.2 p.209

---

Raw frequencies		Totals
AAA: 11	AAB: 6	starting with AA: 17
ABA: 7	ABB: 8	starting with AB: 15
BAA: 6	BAB: 8	starting with BA: 14
BBA: 8	BBB: 0	starting with BB: 8

---

# Table 14.4 Observed Transition Probabilities for Order 2 Markov Model.

Last 2 letters	Next letter	
	A	B
AA	0.75	0.25
AB	0.5	0.5
BA	0.25	0.75
BB	1	0

# Table 14.5 Hidden Markov Model for British Summer Weather – Hidden State in Brackets (Changeable/Wet).

---

Current weather	Tomorrows weather			
	Sun (Changeable)	Rain (Changeable)	Sun (Wet)	Rain (Wet)
Sun (Changeable)	0.3	0.4	0.1	0.2
Rain (Changeable)	0.3	0.3	0	0.4
Sun (Wet)	0.2	0.1	0.1	0.6
Rain (Wet)	0	0.1	0	0.9

---

# Table 14.6 High-level Classification of Periods of Data as a Coarse-grained Time Series

---

D-723	high-rate, normal pattern (strenuous activity)	–	15 mins
D-724	low-heart rate (rest)	–	30 mins
D-725	tachycardia (problem)	–	2 mins
...	...		...

---

# Table 14.7 Weather Transition Probabilities for Use in Exercise 14.1

Current weather	Tomorrows weather			
	Sun (Changeable)	Rain (Changeable)	Sun (Wet)	Rain (Wet)
Sun (Changeable)	1/3	1/3	1/6	1/6
Rain (Changeable)	1/3	1/3	0	1/3
Sun (Wet)	1/6	1/6	1/6	1/2
Rain (Wet)	0	1/6	0	5/6