

Introducing Hidden Markov Models

First – a Markov Model

A **Markov Model** is a chain-structured process where future states depend only on the present state, not on the sequence of events that preceded it.

The X at a given time is called the **state**.
The value of Xn depends only on Xn-1.

State: sunny cloudy rainy sunny ?

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The Markov Model

State: sunny sunny rainy sunny ?
90 % sunny
10% rainy

State transition probability (table/graph)
(The probability of tomorrow's weather given today's weather)

Output format 1:

Today	Tomomow	Probability
sunny	sunny	0.9
sunny	rainy	0.1
rainy	sunny	0.3
rainy	rainy	0.7

Output format 2:

	sunny	rainy
sunny	0.9	0.1
rainy	0.3	0.7

Output format 3:

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The Markov Model

State: sunny cloudy rainy sunny ?
80 % sunny
15% cloudy
5% rainy

State transition probability (table/graph)

Output format 1:

Today	Tomomow	Probability
sunny	sunny	0.8
sunny	rainy	0.05
sunny	cloudy	0.15
rainy	sunny	0.2
rainy	rainy	0.6
rainy	cloudy	0.2
cloudy	sunny	0.2
cloudy	rainy	0.3
cloudy	cloudy	0.5

Output format 3:

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The Hidden Markov Model

A **Hidden Markov Model** is a Markov chain for which the state is only partially observable.

A Markov Model

A Hidden Markov Model

Hidden states : the (TRUE) states of a system that can be described by a Markov process (e.g., the weather).

Observed states : the states of the process that are 'visible' (e.g., umbrella).

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The Hidden Markov Model

	sunny	rainy	cloudy
sunny	0.8	0.05	0.15
rainy	0.2	0.6	0.2
cloudy	0.2	0.3	0.5

State transition probability table

Hidden States

Observed States

State emission probability table

	sunglasses	T-shirt	umbrella	bucket
sunny	0.4	0.4	0.1	0.1
rainy	0.1	0.1	0.5	0.3
cloudy	0.2	0.3	0.1	0.4

The probability of observing a particular observable state given a particular hidden state

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The Hidden Markov Model

The probability of switching from one state type to another (ex. Exon - Intron).

	exon	5'SS	intron
exon	0.9	0.1	0
5'SS	0	0	1
intron	0	0	0.9

State transition probability table

Hidden States

Observed States

State emission probability table

	A	C	G	T
exon	0.25	0.25	0.25	0.25
5'SS	0	0	1	0
intron	0.4	0.1	0.1	0.4

The probability of observing a nucleotide (A, T, C, G) that is of a certain state (exon, intron, splice site)

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