CMI LAB

UNIVERSITY OF WOLVERHAMPTON
KNOWLEDGE ▪ INNOVATION ▪ ENTERPRISE

6CS012 – Artificial Intelligence and Machine Learning

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NUFFIELD DEPARTMENT OF SURGICAL SCIENCES
Medical Sciences Division

6CS012 – Artificial Intelligence and Machine Learning

Agenda:

- Module Brief
- Marking Criteria
- Lecture 1
- Workshop 1

Outcomes

Lecture 1 will cover:

- Natural intelligence
- Artificial intelligence
- Observation and approximation
- Deterministic models
- Stochastic models
- Bernoulli distribution
- Dependent and independent variables
- Markov Chain

Natural intelligence?

– A Quick Realization

Human Driving Behaviour

Natural intelligence?

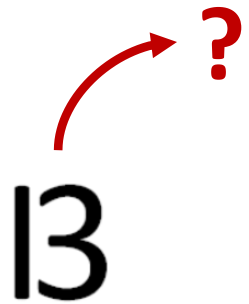
– A Quick Realization

Different Behavioural Expectations

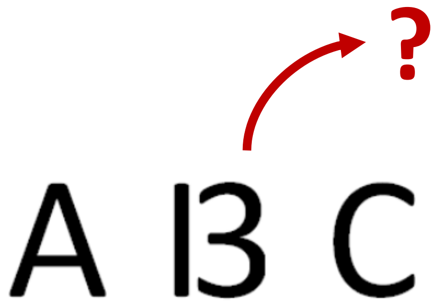
Natural intelligence?

– A Quick Realization

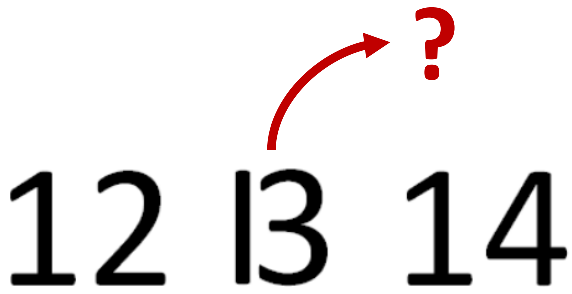
Natural intelligence?
Ambiguous Decision-Making



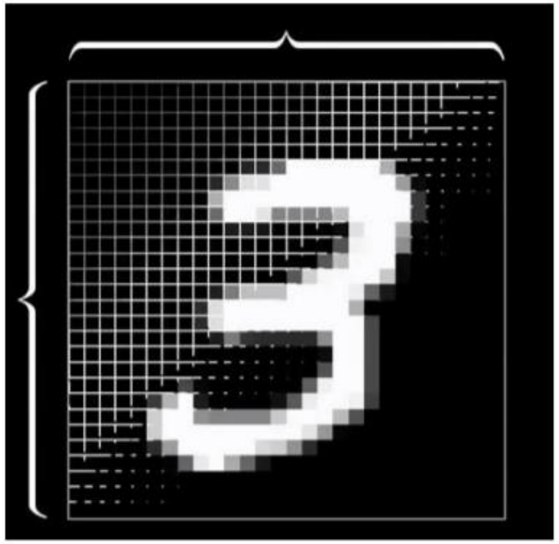
Natural intelligence?
Ambiguous Decision-Making



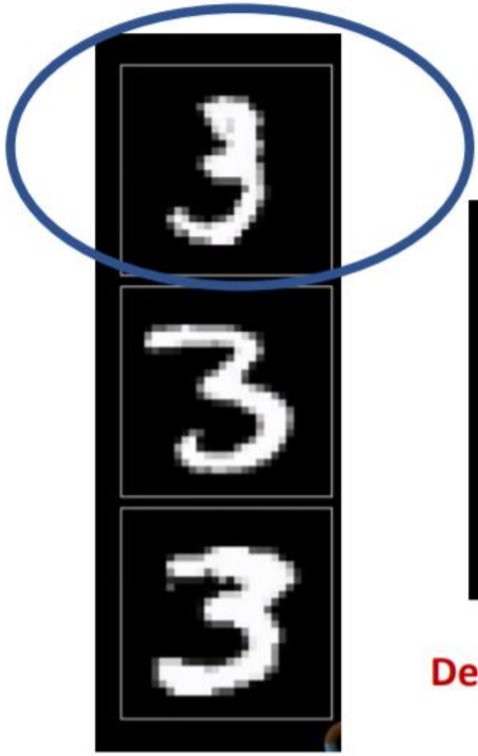
Natural intelligence?
Ambiguous Decision-Making



Natural intelligence?
Ambiguous Decision-Making



A very low resolution clearly written digit 3



Despite their specific values being very different

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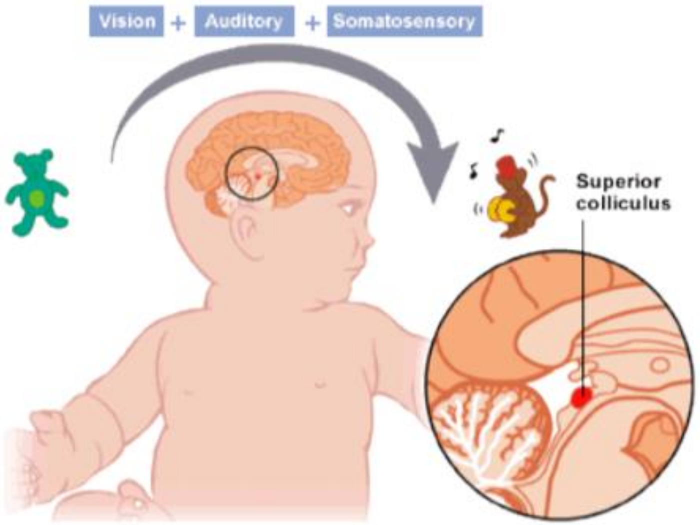
What are we doing?

Making sense of the outside world

(Based on our beliefs about how the outside world is!)

Complying with the anticipated behavior
(based on past learning and reasoning)

Natural Intelligence?



Early brain development and pattern recognition

Mom

Dad

Cat

Dog

Artificial Intelligence?

How do we do it?

Observation and Approximation

- Our observation about the outside world
- Beautiful dichotomy → no two things are exactly alike

- But they certainly follow some underlying pattern that we learn and make sense of!

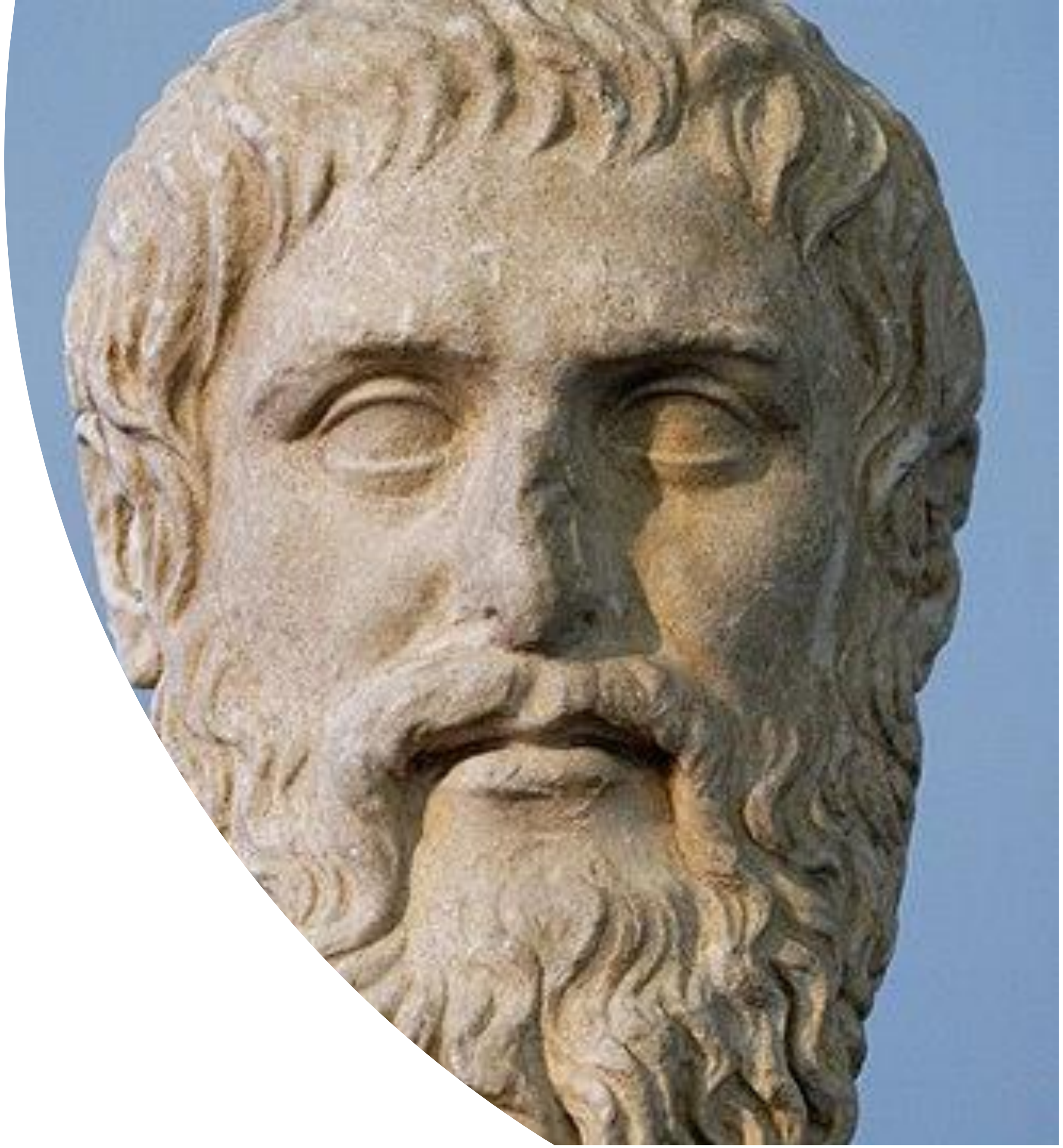
Observation and Approximation

- **Deterministic models vs. Stochastic models** → Our brain, is not a deterministic model rather stochastic.

- It is more practical to use **a simple but uncertain rule rather than a complex but certain one**.
  - E.g. simple rule "<u>most birds fly</u>" is cheap to develop rather,
  - "<u>birds fly except young birds that have not yet learned to fly, sick or injured birds that have lost the ability to fly or flightless species including ostrich, kiwi etc.</u>“, and still the complex model will be prone to failure in some cases.

Observation and Approximation

- “Plato believed that the true form of the universe were hidden from us. Through observation of the natural world, we could merely acquire approximate knowledge of them” [1]



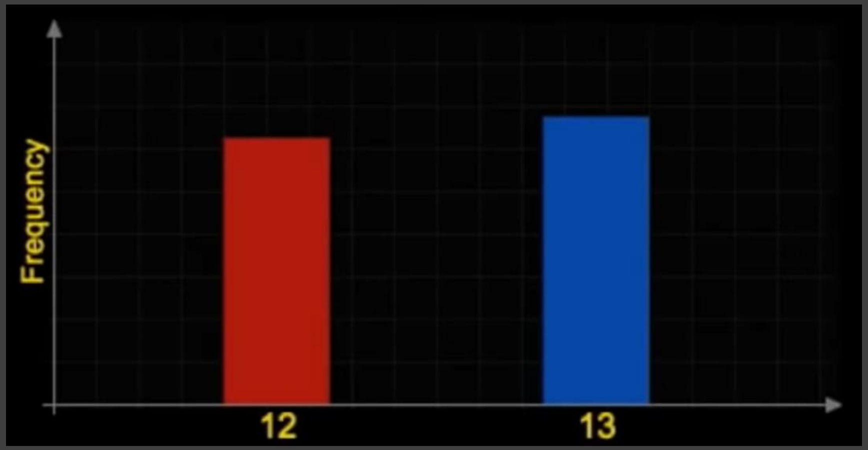
Born 427 BC; Died 348 BC

Let’s Play A Game Called ‘Observation’

- Suppose that without your knowledge, XXX Almonds and YYY Pistachios are hidden in a bag.

- How can we determine the ratio of Almonds versus Pistachio?

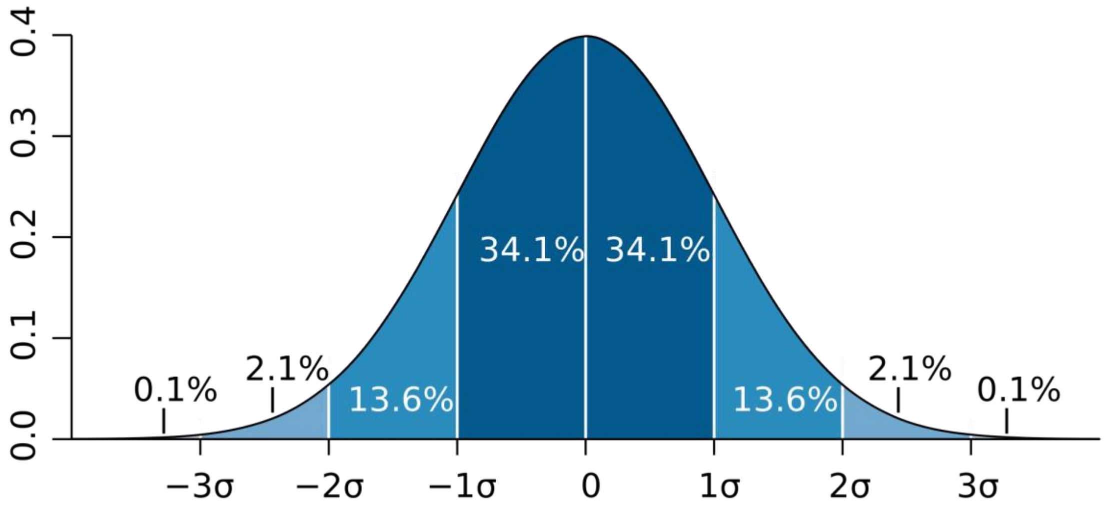
Weak law of large numbers

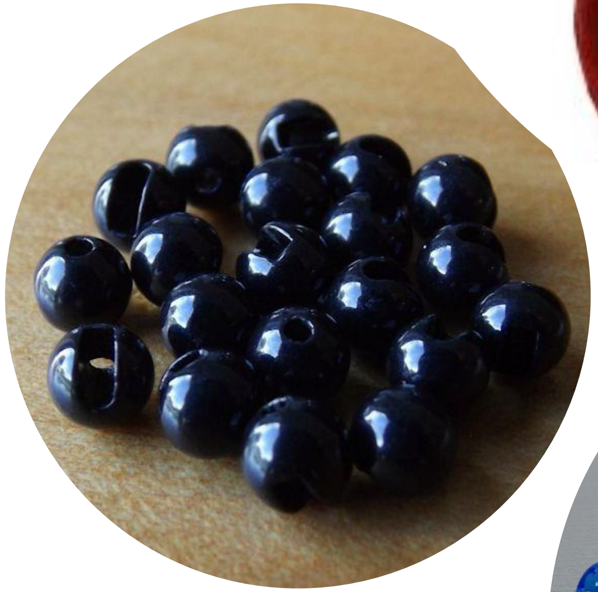


Observation and Approximation

- **Bernoulli (1654 - 1705)** proved that if the observation of all events continues to infinity, you will see that everything in the world governs a precise ratio.

- It's like a pre-determined statistical fate!



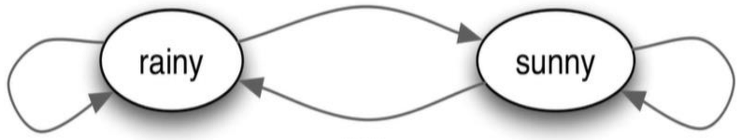


Observation and Approximation (Dependence vs. Independence)

- **Pavel Nekrasov (1853–1924),** didn't like the idea of predetermined statistical fate.

- He made a famous claim that '**independence**' is a necessary condition for the convergence.

- As most things in the real-world are clearly '**dependent**' on prior outcomes, e.g., weather, stock market etc.

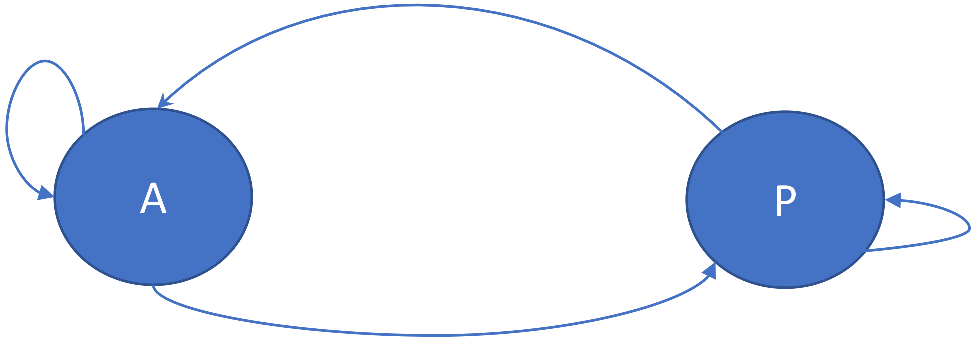


Observation and Approximation (Dependence vs. Independence)

- **Andrey Markov (1856–1922)** proved that the law of large numbers can apply "to dependent variables“ as well!

- He extended Bernoulli's results to dependent variables using an ingenious construction.

Observation and Approximation (Dependence vs. Independence)



- Now, we assume having two states:
  - (1) 50-50 mix of Almonds versus Pistachios
  - (2) More Pistachio versus Almond (we don't know how many more, just random).
- One State is called State '**P**' that represents a Pistachio having previously occurred, and the other, we call State '**A**' that represents an Almond having previously occurred.
- Start a game and make a random selection from the two states (i.e. draw one nut randomly). Place it back, and move to either state **P** or **A**, depending on the last event. With this two-state machine, we can identify four possible transitions.

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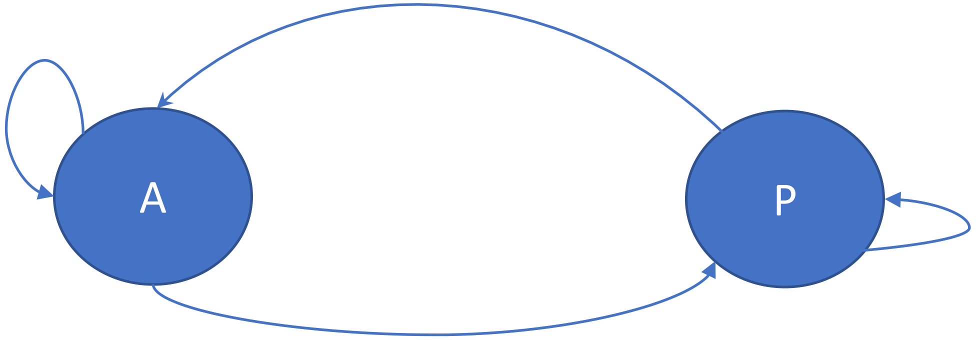
Observation and Approximation (Dependence vs. Independence)

- **As the number of trials increases and N-->infinity, the number of times you visit each state converges to some specific ratio or a probability.**



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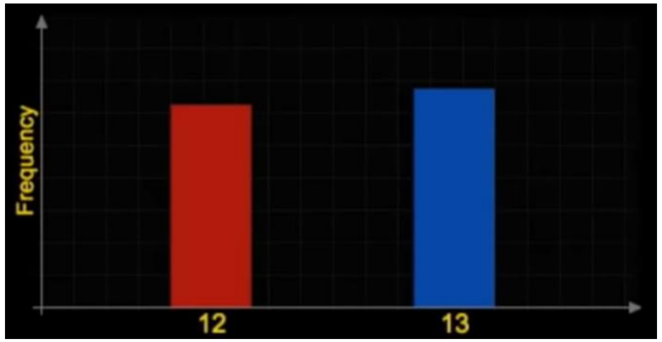
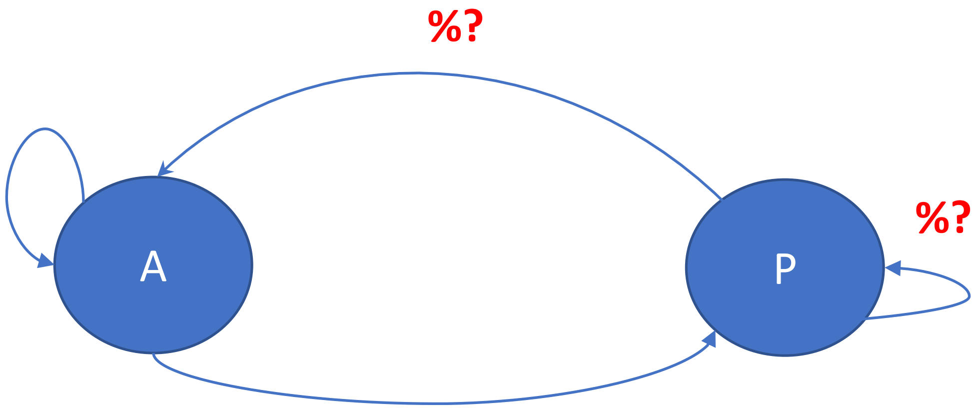


A vs. P

Observation and Approximation (Dependence vs. Independence)



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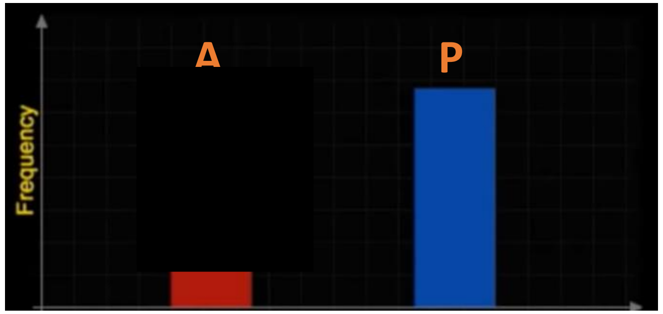
1. Total trials =
2. Total Almonds = %
3. Total Pistachios = %



1500 8500

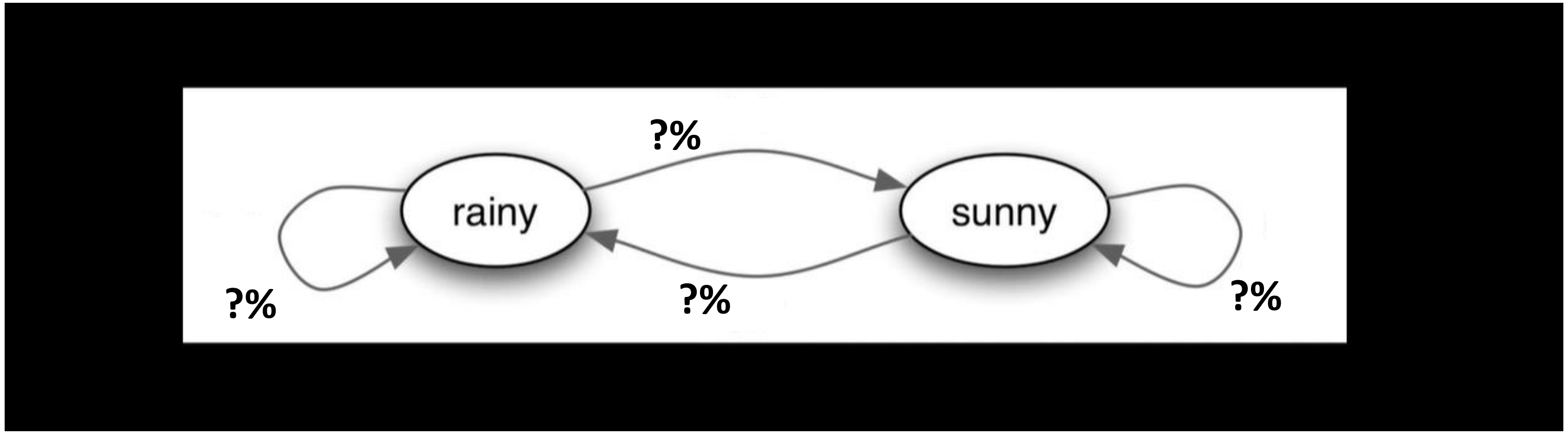
A vs. P

N→ ∞

- The system will converge (or will reach a steady-state)
- A true form/precise ratio!

Markov Chain

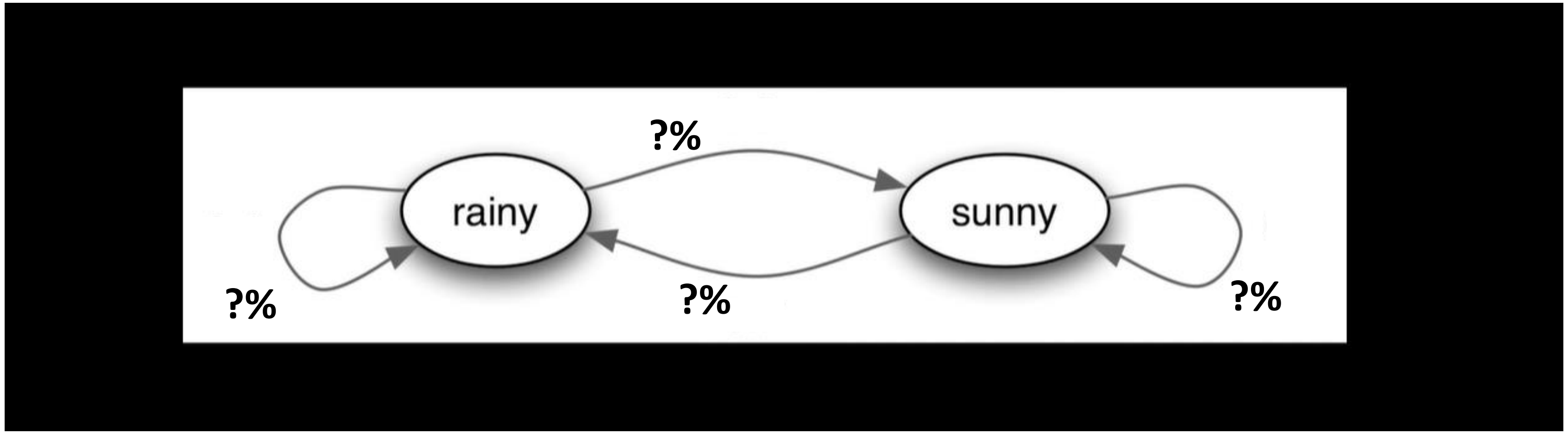
- Dataset = {RSRSRRSS}



- X^0 = [1 0] (**Day 1: Sunny**)
- Transition matrix = [? ?; ? ?]
- $X^{1,}$ X^2,........,X^n ?
- $X^n = X^{n-1}.T$
- $X^n = X^0.T^n$

Markov Chain

- Dataset = {RSRSRRSS}



- $X^0 = [1\ 0]$
- $T = [0.25\ 0.75;\ 0.66\ 0.33]$
- $X^{1,} X^2, \ldots\ldots, X^n$?
- $X^n = X^{n-1}.T$
- $X^n = X^0.T^n$

References

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