Nothing is random, not even rolling a dice

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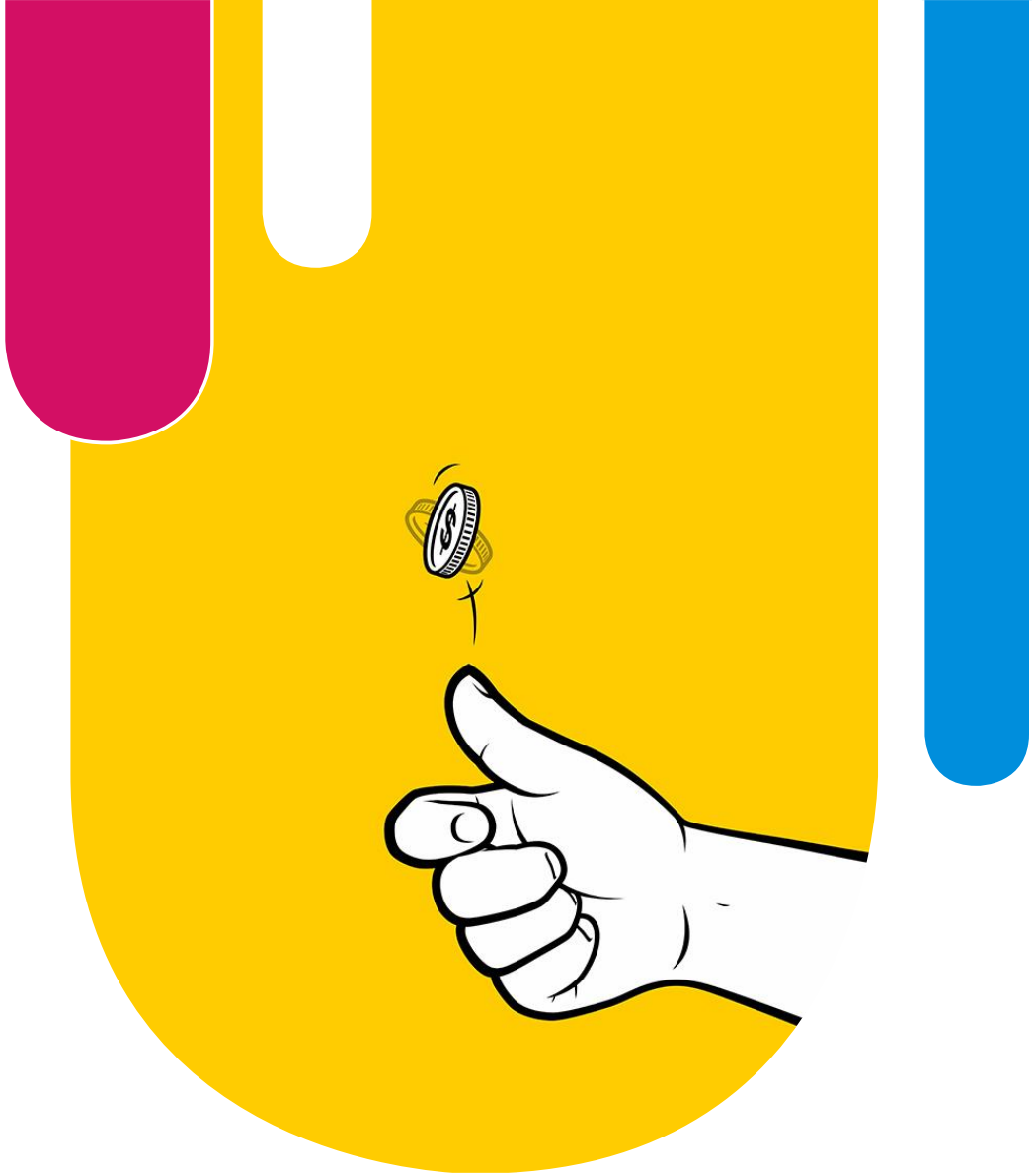
Randomness in our life

- Almost everything that we call “Good luck” or “Bad luck”
- Winning a lottery
- Playing a game of chance such as Backgammon, Poker, etc.
- Watching games such as a football match
- Selecting an arbitrary decision among many, without any priority
- Interpreting someone else behavior
- and so on…

* Games mentioned here are not purely games of chance, but a mixed of chance and skills.

Questions?

- What is randomness?
- How is a random number selected?
- Is a random event random?
- Why should I care about it?
- What can I do with it?
- Can I predict a random result?
- What should I be aware of?



What is randomness?

- "Randomness is the apparent lack of pattern or predictability in events."
- "Individual random events are by definition unpredictable, but since they often follow a probability distribution, the frequency of different outcomes over numerous events (or "trials") is predictable.“
- Prof. Theodore Motzkin pointed out that ***"while disorder is more probable in general, complete disorder is impossible"***.

- https://en.wikipedia.org/wiki/Randomness
- Hans Jürgen Prömel (2005). "Complete Disorder is Impossible: The Mathematical Work of Walter Deuber". Combinatorics, Probability and Computing. Cambridge University Press. 14: 3–16. doi:10.1017/S0963548304006674.

History

- The Chinese of 3000 years ago were perhaps the earliest people to formalize odds and chance.
- The Greek philosophers discussed randomness at length.
- It was only in the 16th century that Italian mathematicians began to formalize the odds associated with various games of chance.
- In the 20th century computer scientists began to realize that the deliberate introduction of randomness into computations can be an effective tool for designing better algorithms.

Photo: Dice players. Roman fresco from the Osteria della Via di Mercurio (VI 10,1.19, room b) in Pompeii.

Applications

- *Physical Sciences*
- *Biology*
- *Information Science*
- *Mathematics*
- *Statistics*
- *Finance*
- *Politics*
- *Medicine*
- *Games*
- *Religion*

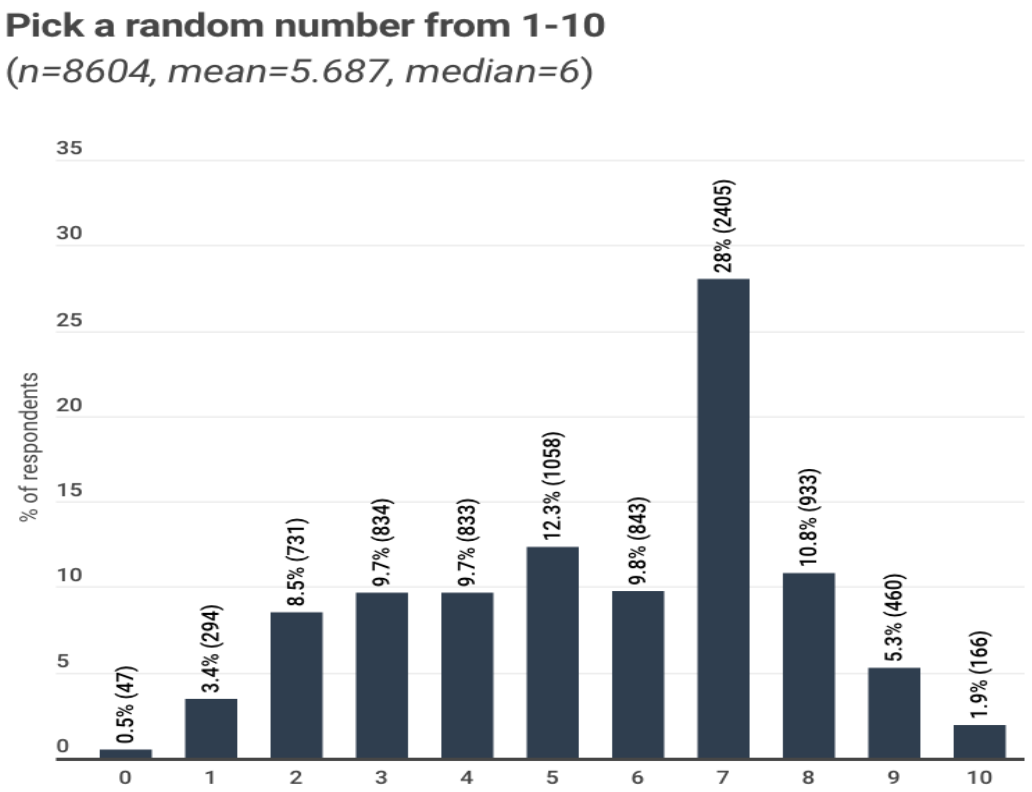
https://en.wikipedia.org/wiki/Randomness

Randomness process: human

- Let's assume that someone asks you to choose a random number between 0 and 10.
- Now, you have selected a number, let's say it is "8".
- How did you select your number?
- What was your thought process?
- Nobody knows exactly how a person can develop a random generator to select or generate a random number.
- One possible scenario might be that people tend to select an "*uncommon*" number.
- The factors involved can be mood, fatigue, recent conversation, past experiences.

"Human Behavioral Complexity Peaks at Age 25", N. Gauvrit, H. Zenil*, F. Soler-Toscano, J.-P. Delahaye, P. Brugger. PLoS Comput Biol 13(4): e1005408, 2017. (PLOS)

The most common random number



- 1 - well it is just one
- 2 - all even numbers are divisible by 2
- 3 - is a prime but also in 6 and 9
- 4 - is a cube
- 5 - we have 5 fingers
- 6 - is 3*2
- 8 - is 4*2 or a power of 2
- 9 - is a cube
- 10 - our system is in base 10

- **But 7 seems exotic**

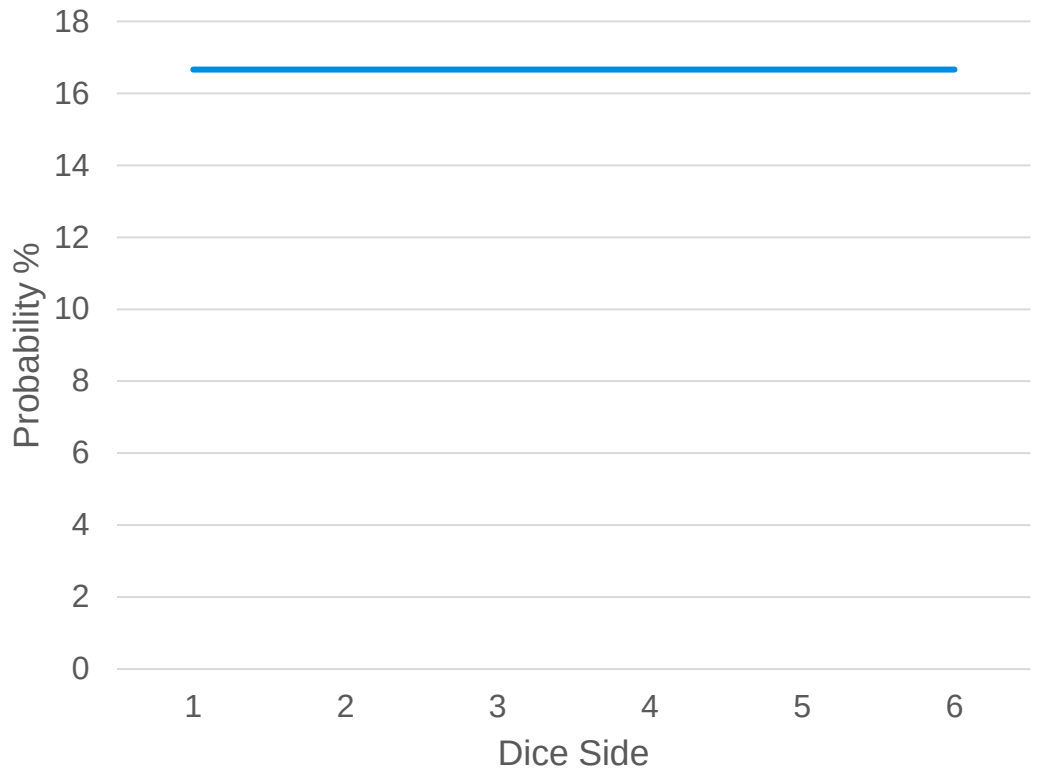
SOURCE: https://www.reddit.com/r/dataisbeautiful/comments/acow6y/asking_over_8500_students_to_pick_a_random_number/ed9n0i1/

Randomness process: computer

- Computers use algorithms to generate a random number. Yes, that's right, they calculate a random number.
- Computers can generate random numbers by observing some internal data such as date/time, CPU serial number, hardware specifications and as well as some outside data, like mouse movements or fan noise, which are not easily predictable.
- This is known as "*pseudorandom*" generation.
- In Oxford dictionary, "*pseudo-random*" means: "***(of a number) satisfying one or more statistical tests for randomness but produced by a definite mathematical procedure.***"
- So, the results appear random, even though they are not.

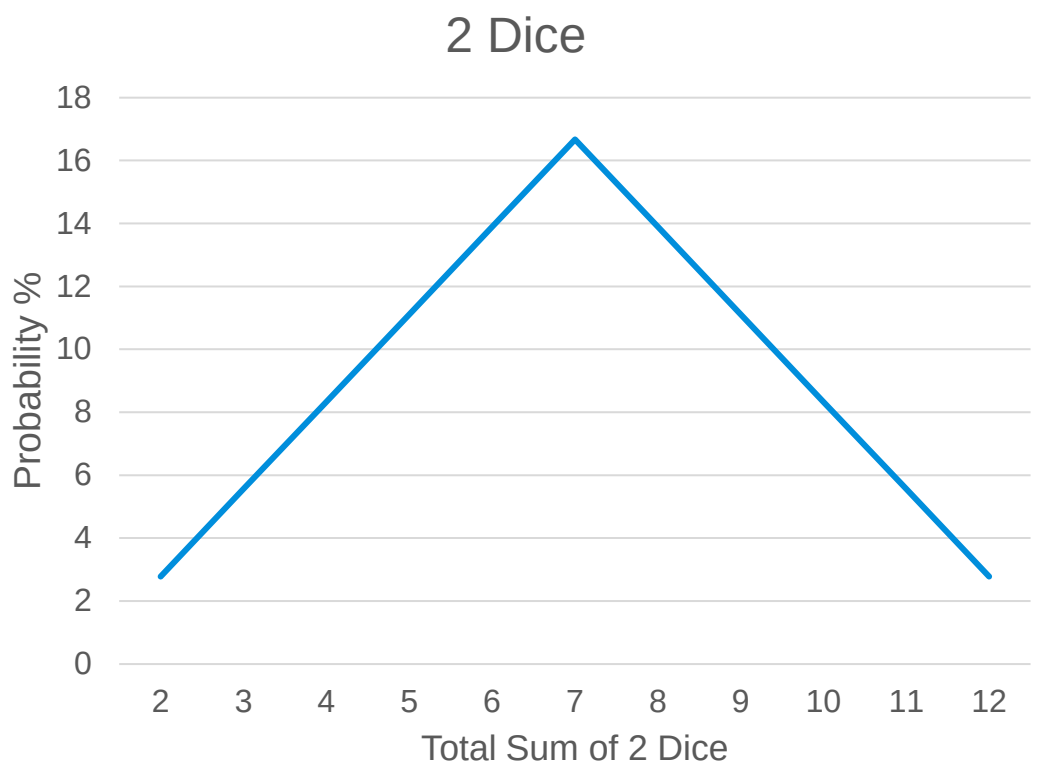
"pseudo": non genuine; spurious or sham

Random Generation: 1 Dice

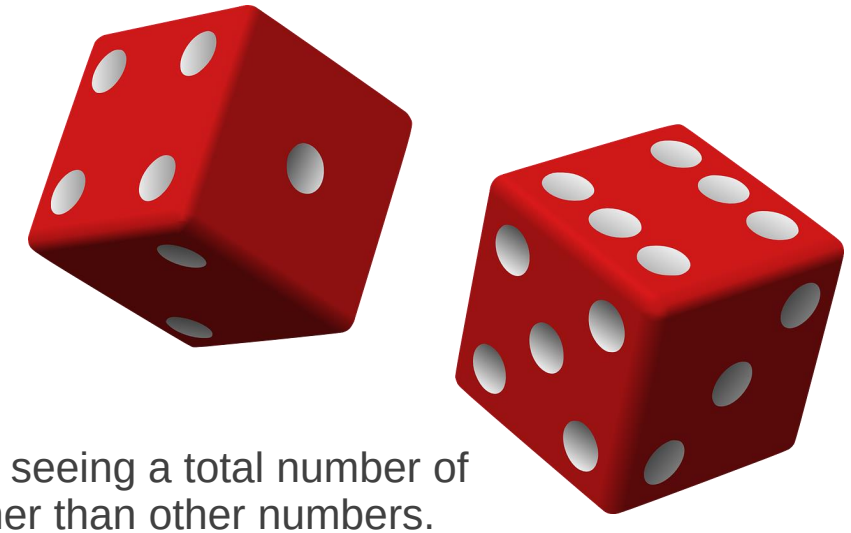


- The chance for each number to show up is 1/6
  - 1/6 = 0.1666
  - ~ 16.66 % of chance for each number
- If you throw a fair dice *“n”* times, there is an equal chance of seeing all numbers.

Random Generation: 2 Dice

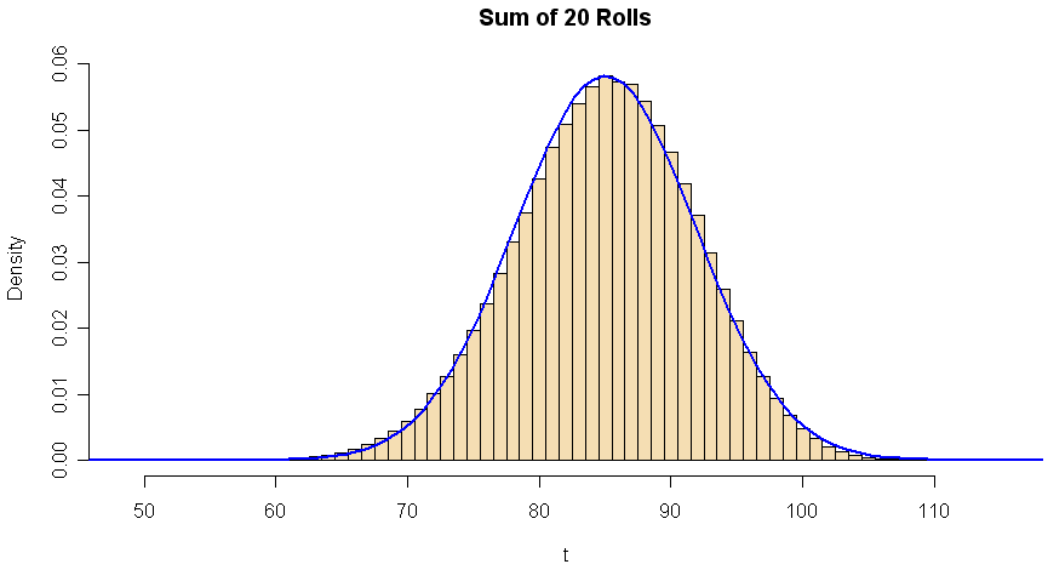


- When you throw 2 dice, the total number is between 2 and 12.
- 6 Combinations for the sum of “7”
  - 6 – 1
  - 5 – 2
  - 4 – 3
  - 3 – 4
  - 2 – 5
  - 1 – 6



- The chance of seeing a total number of 7 is much higher than other numbers.

Random Generation: n-Dice



- Rolling 50 six-sided dice

$$\mu = 50 \times \frac{7}{2} \qquad \sigma = \sqrt{50 \times \frac{35}{12}}$$

- As we increase the number of dice, the probability distribution of numbers shown up is becoming more like Gaussian normal distribution.

2 Dice vs 12-Sided Dice

≠

The chance of having a generated number using 2 6-side dice is not equal to using a 12-side dice.

Let’s look at rolling a die

“The die throw is neither random nor chaotic.” *

When you throw a die, physics rules apply to the die motion.

Some of the important factors are:

- The shape of dice
- The amount and angle of force throwing the dice
- Velocity and acceleration of hand while throwing
- Vertical distance to the surface
- Viscosity of the air
- Friction and elasticity factors of the table
- The initial position of die

* Kapitaniak, M., Strzalko, J., Grabski, J., & Kapitaniak, T. (2012). The three-dimensional dynamics of the die throw. Chaos: An Interdisciplinary Journal of Nonlinear Science, 22(4), 047504.

Is random, truly random?

- By a definition of the word random in this context, it means that, in terms of cause and effect, an effect must occur without any cause.

- In a deterministic universe, at a macroscopic level, this is **impossible**.

Can randomness be predicted?

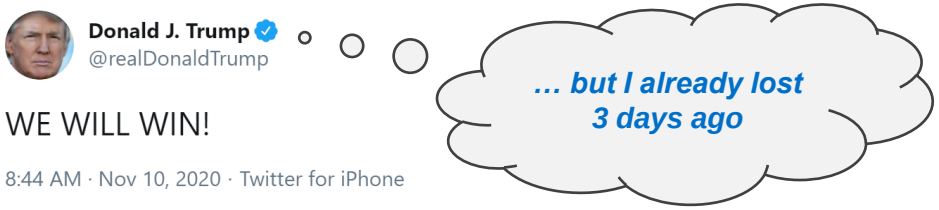
Random must be unpredictable or at least very difficult to be predicted!

- Most of the randomness that we observe is more "*Chaotic*" rather than *"Random"*.
- All these randomness (or better to say pseudo-randomness) are based on some complex reasons.
- Theoretically, if we can access the pseudo-randomness features, we can predict that.

- If something is **truly random**, it is **impossible** to be predicted.
- If something is **pseudo-random**, it is designed to be **almost impossible** or at least **super difficult** to be predicted.

Photo: **"I REALLY DON'T CARE, DO U?"** - Melania Trump, US President's wife, walked to her plane at Andrews Air Force Base in Maryland wearing that jacket.
https://www.cosmopolitan.com/politics/a21755998/donald-trump-responds-melania-jacket/

Why should I care?



- If anyone can predict the next random value:
  - She can win the games in casino
  - She can win the lotteries
  - There would be no ***security whatsoever***
    - Online
    - Banking/Card payments
  - No optimized algorithms
  - No powerful artificial intelligence (AI)
  - Noisy telecom communications (if there is any)
  - And many more.

Black Box: Secret Recipe

- Intel chips hardware-based random generator: “RdRand”
- Usually, production level random generators are essentially a black box, and no one knows what is going on inside.
- In December 2013, FreeBSD’s developers removed support for using RdRand directly as a source of randomness, saying they could not trust it.
- FreeBSD’s developers called out Via’s chips too.

- This controversy shows why generating random numbers that are random and not predictable is very important.

https://en.wikipedia.org/wiki/RDRAND

Randomness and Artificial Intelligence

- Randomness has proven a useful component in machine learning
- Any feasible Artificial General Intelligence (AGI) would likely require machine learning
- Randomness is necessary to achieve generality in theory

Can randomness be predicted by AI?

- If any system (either intelligent or dumb) can predict the randomness, then that was not random in the first hand.

How can we identify if an event is random then?

….

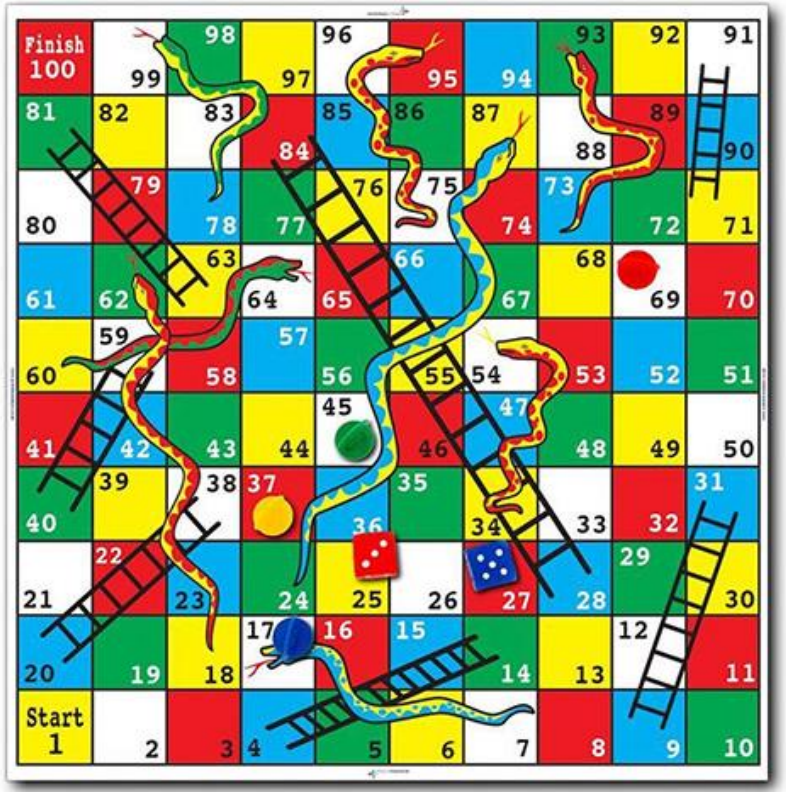
FIFA World Cup Prediction

- Sometimes, some events have multiple complex features which we may not be aware of them. Exactly like rolling a dice.
- But unlike dice, we do not call them random, because we have some limited knowledge about them. Such as FIFA World Cup.
- If you want to predict the FIFA World Cup, you can do it, only if you can predict every match correctly. If you fail the prediction in one match, it is very likely that you will fail in the finals.
- Even for predicting a single match, we should know about the team history, players' characteristics and strength, personal problems, weather forecast, how likely a player may make a wrong decision leading to a red card or penalty, and so many more.
- Unless we know about all affecting factors, we can not predict such complex outcomes.
- … and that's why they fall into a "*Markov chain*".

https://medium.com/@bakhtiyari/artificial-intelligence-failed-in-world-cup-2018-6af10602206a

Markov Chain *

- A “*Markov chain*” is a model describing a sequence of possible events in which the probability of each event depends only on the state attained in the previous event.
- Markov chains have many applications in real-world processes, such as studying cruise control systems in motor vehicles, queues or lines of customers arriving at an airport, currency exchange rates and animal population dynamics. **
- Markov chains can be used to model many games of chance. *“Snakes and Ladders”* is represented exactly by Markov chains.

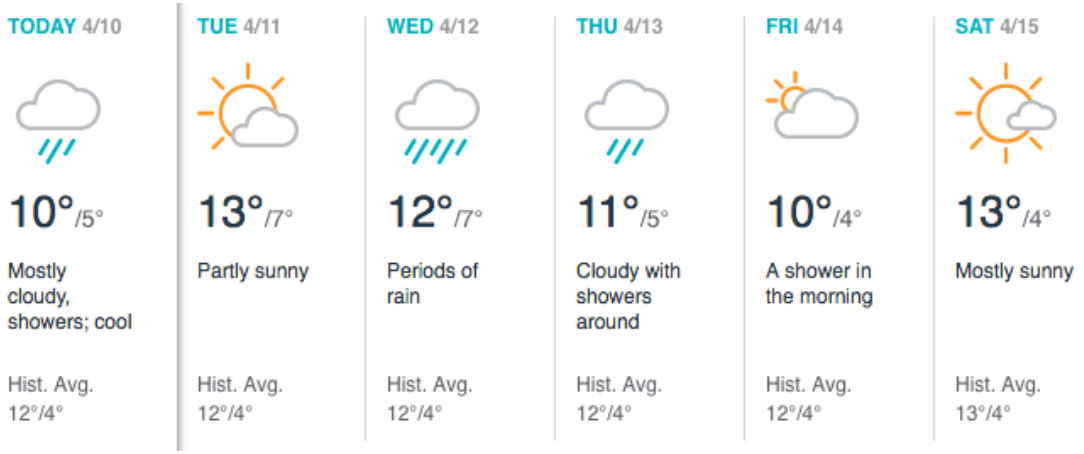


* It is named after the Russian mathematician Andrey Markov.

** Sean Meyn; Richard L. Tweedie (2 April 2009). Markov Chains and Stochastic Stability. Cambridge University Press. p. 3. ISBN 978-0-521-73182-9.

Weather Forecast

- The other example of “Markov Chain” is the weather forecast
- You can only forecast the weather accurately, if you could do it correctly for its previous days.



- As we try to forecast the weather in a far future, then it could be like predicting the FIFA World Cup winner before it has been started, or even one year in advance.
- As we get closer and closer to each day, the weather forecast will become more accurate since the number of hidden/unknown factors would be minimized.

Lesson Learned

Do not expect a precise prediction using AI if your target outcome is near to random

- If there is not enough information or reasoning about an event, the outcome can be defined as random.
- As discussed, there is nothing truly random, however sometimes actions may fall into the random definition based on the available knowledge.
- A football match by itself is not random, and it is mostly based on skills.
- However, predicting the result of a match or forecasting the weather one year from now, seems random to us.
- If there is something random or pseudo-random, do not expect any system (either human or AI) to predict it accurately.

Is there anything truly random?

- Short answer: **Almost yes**
- Decay rate of radioactive materials
- In quantum theory, quantum properties that are random are truly random
- The time between decays of atoms in a sample of a radioisotope or thermal noise in a resistor.
- These are fundamentally random.

https://plato.stanford.edu/entries/determinism-causal/#ConIssDet

Next time, when you are in a casino, watch those who seem very lucky, notice that it is not only luck, but they probably know (or feel) more of the hidden factors than the rest of the people there.

Q&A

This photo was shot at a casino in Macau!

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