<u>The Monty Hall Problem and Conditional Probability in Fraud Detection</u>

Probability & Statistics for Data Science

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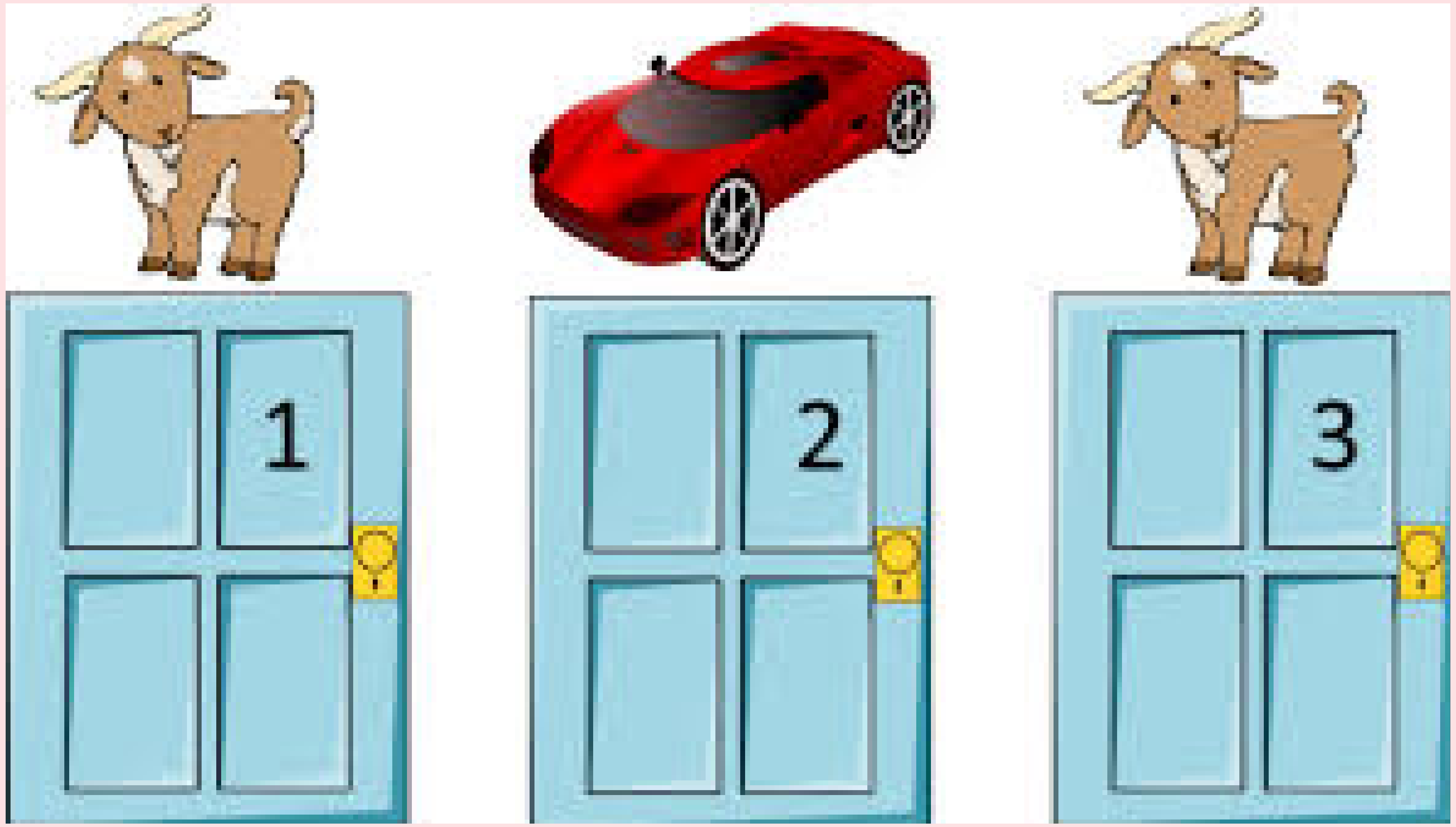
In this lesson...

We will explore how to:

- Explain the **Monty Hall problem** and why switching doors increases winning probability.
- Apply **Conditional Probabilit**y to real-world decision-making and simulate probability scenarios using **Python.**
- Relate the Monty Hall logic to **fraud detection and credit alert systems** and understand how to make decisions .

Monty Hall Problem: Understanding Conditional Probability



You are on a game show. There are 3 doors, behind one is a car and the others have goats. You pick a door. The host opens another door to show a goat. Do you stay or switch?

Solution:

Step 1: Initial Probabilities

Picked Door: 1 P(Car behind 1) = 1/3

Other Doors: 2 & 3 P(Car behind 2 or 3) = 2/3

Step 2: Host Opens Door 3 (Goat)

P(Car behind 1 | host opens goat) = 1/3

P(Car behind 2 | host opens goat) = 2/3

Step 3: Decision

Stay with Door 1 → 1/3 chance of winning

Switch to Door 2 → 2/3 chance of winning

What is Conditional Probability?

Conditional Probability is the probability that an event A occurs given that another event B has already occurred.

In other words:
Focus only on the cases where B happens, then see how many of those also satisfy A.

Example in the Monty Hall problem:
– A = "Car is behind my chosen door"
– B = "Host opens a door showing a goat"
Then P(A|B) = Updated probability after new information

Formula:

$$P(A|B) = \frac{P(A \text{ and } B)}{P(B)}$$

Where:
– P(A|B) = Probability of A given B
– P(A and B) = Probability that both A and B happen
– P(B) = Probability that B happens

Real-World Use Cases

1. Fraud Detection in Banking:

SCENARIO :

KCB Bank wants to detect fraudulent transactions. The alert system should flag suspicious transactions.

Events:

- A = Transaction is actually fraudulent
- B = Transaction is flagged by the system

Question: What is the probability that a transaction is fraudulent given that it was flagged?

Formula:

$P(A \mid B) = P(A \cap B) / P(B)$

Example:

- $P(A) = 0.01$ (1% of transactions are fraudulent)
- $P(B \mid A) = 0.9$ (system catches 90% of fraud)
- $P(B \mid \text{not } A) = 0.05$ (system falsely flags 5% of legitimate transactions)

Solution:

Step 1: Compute $P(A \cap B)$

$P(A \cap B) = P(A) \times P(B \mid A) = 0.01 \times 0.9 = 0.009$

Step 2: Compute $P(B)$

$P(\text{not } A \cap B) = P(\text{not } A) \times P(B \mid \text{not } A) = 0.99 \times 0.05 = 0.0495$

$P(B) = P(A \cap B) + P(\text{not } A \cap B) = 0.009 + 0.0495 = 0.0585$

Step 3: Compute Conditional Probability

$P(A \mid B) = P(A \cap B) / P(B) = 0.009 / 0.0585 \approx 0.154$

Interpretation: Even though the system flagged the transaction, there's only ~15.4% chance it's actually fraud.

This shows the importance of conditional probability: the raw alert doesn't tell the full story; you need to update probabilities based on system accuracy and base fraud rate

Other Real World Applications:

1. **Medical Testing:** Probability a patient has a disease given a positive test
2. **Spam Filtering:** Probability an email is spam given it was flagged
3. **Insurance Risk:** Probability a driver files a claim given prior violations
4. **Credit Scoring:** Probability a borrower defaults given past payment history
5. **Marketing:** Probability a customer buys a product given they clicked an ad

Any Questions?

Resources

The Monty Hall Problem : https://youtu.be/9vRUxbzJZ9Y?si=huTGDjYjrF_pF0PA

Conditional Probability: https://youtu.be/ibINrxJLvlM?si=QcvX2lJE4LjYV-zK
https://youtu.be/sqDVrXq_eh0?si=k-N9v50YAqcMpRLP

Python Notebook:
https://colab.research.google.com/drive/1pvgjiG7ubcO_9fp_drbrIO2GG_2QjoXS?usp=sharing

Github Repository:

THANK YOU