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ML Math Club: Probability Fundamentals

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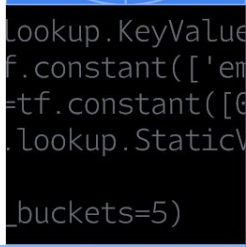

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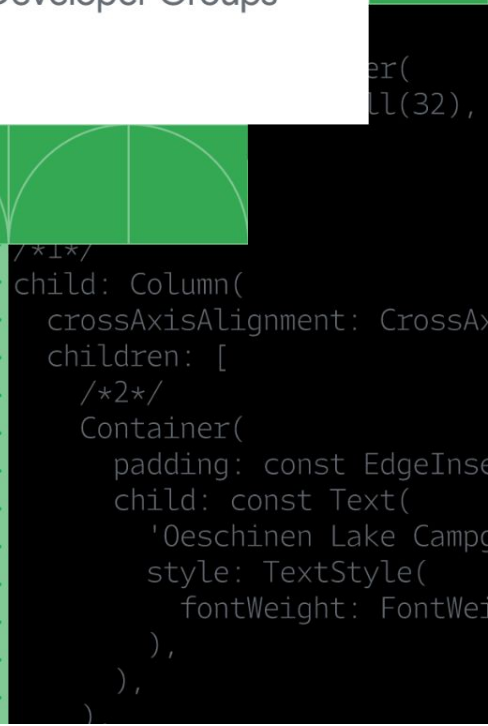

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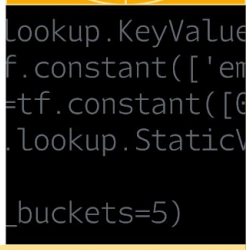
Introduction to Probability



Definition:

The measure of how likely it is that an event will happen.

It's a way of quantifying uncertainty. We often express probability as a number between 0 and 1, where:

-0 means the event is impossible.

-1 means the event is certain.

Why Does Probability Matter?

-Helps model **uncertainty** in real-world scenarios.

- Forms the **foundation** of statistics & machine learning.

- Used in **decision-making** and AI models.

-etc.

Real-World Applications:

Weather Prediction: Forecasting based on historical data.

Spam Filtering: Classifying emails as spam/non-spam using Bayes' Theorem.

Recommendation Systems: Predicting user preferences in Netflix, Spotify, etc.

Example:

- If it's cloudy, what's the probability of rain? 🌧️
- Based on past data: **P(Rain | Cloudy) = 70%**

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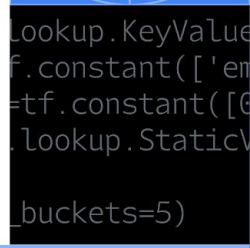
Basics of Probability Theory



Sample Space & Events

The general formula for calculating probability is:

P = A/S

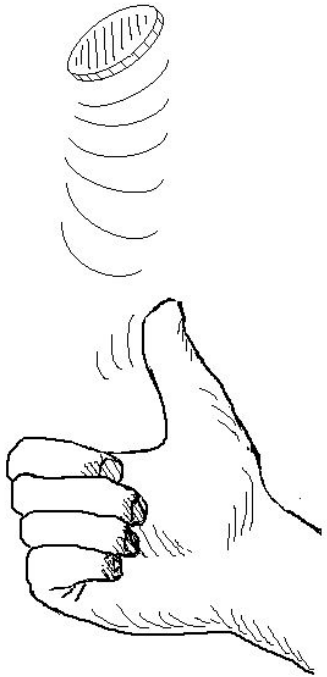
Sample Space (S) → Set of all possible outcomes.
Event (A) → A subset of the sample space.

Example (Coin Flip)

Sample space: S={P,F}

Event: Getting A={P}

Probability: P(A)=0.5

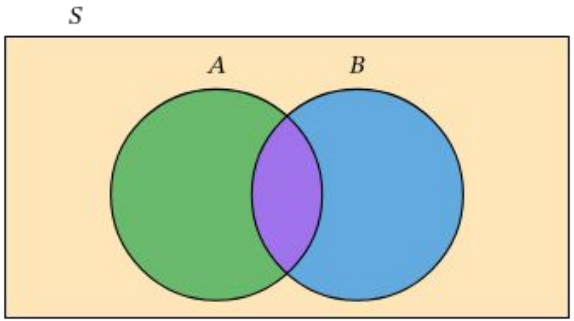


Probability Axioms

-The probability of any event is between 0 and 1.

-The probability of the sample space is 1.

$$P(A \cup B) = P(A) + P(B) - P(A \cap B)$$



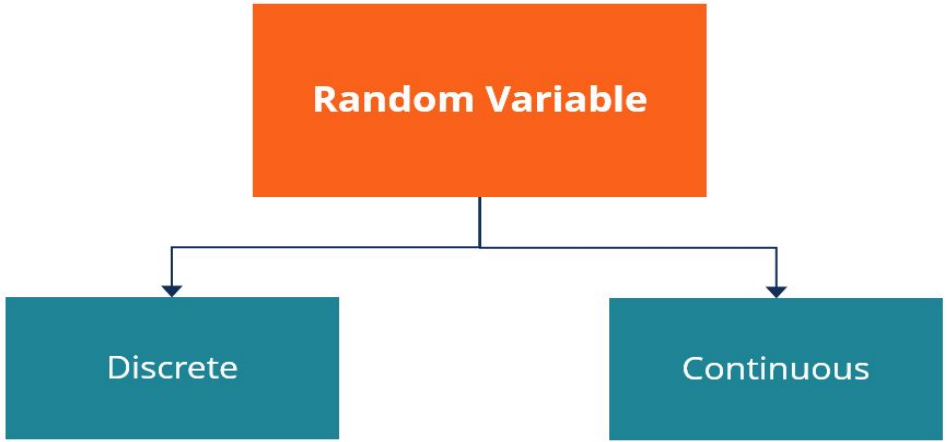
Example (Rolling a Die)

Sample space: S={1,2,3,4,5,6}

Rolling a 4 or a 6 on a Die

P(4 ∪ 6)=P(4)+P(6)=⅙+⅙ =⅓

What is a Random Variable?



Discrete: Takes countable values

Continuous: Takes values in a range

Discrete vs. Continuous Random Variables

Discrete RV:

Finite or countable set of outcomes.

Example: Rolling a die (values: 1, 2, 3, 4, 5, 6).

Continuous RV:

Infinite possible values within a range.

Example: A person’s weight (e.g., 65.3 kg, 65.31 kg).

https://www.bibmath.net/formulaire/index.php?

https://www.bibmath.net/ressources/index.php?

The number of students in a classroom.

The time taken to complete a marathon

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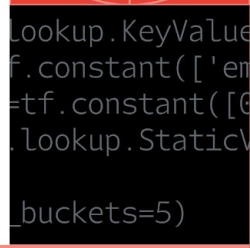
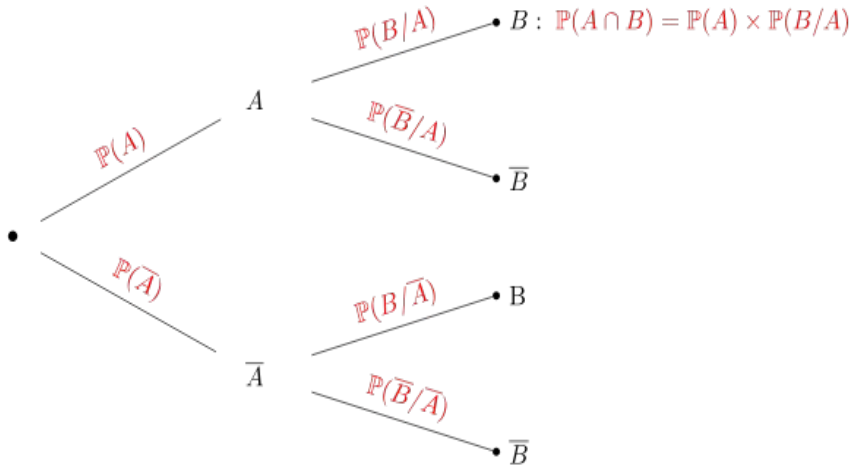
Conditional Probability
&
Bayes' Theorem



What is Conditional Probability?

The probability of an event **A** occurring given that event **B** has already occurred.

$$P_B(A) = P(A|B) = \frac{P(A \cap B)}{P(B)}.$$



Example (Probability of Passing an Exam)

P(Pass | Studied) = High

P(Pass | Didn't Study) = Low

Bayes' Theorem

Bayes' Theorem allows us to reverse conditional probabilities:

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

Spam vs Not Spam

with

NAÏVE Bayes Classifier

Example:

8 emails

3 spam

5 not spam

What's the probability that a randomly selected email would be SPAM?

$$P(S) = \frac{Spam}{Spam + Not\ Spam} = \frac{3}{8} \qquad P(S) = \frac{Not\ Spam}{Spam + Not\ Spam} = \frac{5}{8}$$

NAÏVE Bayes Classifier

Bag of Words:

Email		BOG Features
Hello Friend	→	[1, 1, 0, 0, 0]
Win Prize Money	→	[0, 0, 1, 1, 1]

Vocab

[“hello”, “friend”, “win”, “prize”, “money”]

Bag of Words

Hello Friend

$$P(S) = P(S) * P(\text{hello} \mid S) * P(\text{friend} \mid S)$$

$$P(S) = \frac{3}{8} * \frac{2}{17} * \frac{3}{17} = 0.00778$$

$$P(N) = P(N) * P(\text{hello} \mid N) * P(\text{friend} \mid N)$$

$$P(N) = \frac{5}{8} * \frac{7}{18} * \frac{5}{18} = 0.0675$$

QUIZ!

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If an email contains the words "win" and "free", and we apply the Naïve Bayes formula, what are we calculating?

What does conditional probability measure?

Which of the following is the correct formula for Bayes' Theorem?

Let’s Code !

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```
child: Column(
  crossAxisAlignment: CrossA
  children: [
    /*2*/
    Container(
      padding: const EdgeInse
      child: const Text(
        'Oeschinen Lake Campg
        style: TextStyle(
          fontWeight: FontWei
        ),
      ),
    ),
```