Binomial Distribution Analysis of 100 Coin Tosses

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Abstract

This project explores the Binomial distribution in the context of 100 fair coin tosses. Using Python's `scipy.stats` and `matplotlib`, the Probability Mass Function (PMF) and Cumulative Distribution Function (CDF) are calculated and visualized. This demonstrates the behavior of a large number of binary trials and highlights how the Binomial distribution approximates a normal curve as the number of trials increases.

1 Introduction

The Binomial distribution is a discrete probability distribution that describes the number of successes in a fixed number of independent Bernoulli trials. In this experiment, we simulate the tossing of a fair coin 100 times and analyze the distribution of the number of heads.

2 Objective

To compute and visualize:

- The Probability Mass Function (PMF)
- The Cumulative Distribution Function (CDF)

for the Binomial distribution with $n = 100$ trials and $p = 0.5$ probability of success.

3 Methodology

We used the Python programming language with the following libraries:

- `numpy`: for array manipulations
- `matplotlib.pyplot`: for plotting PMF and CDF
- `scipy.stats.binom`: for computing PMF and CDF

4 Python Code

Below is the Python code used to compute and plot the PMF and CDF:

```
import numpy as np
import matplotlib.pyplot as plt
from scipy.stats import binom

n = 100
p = 0.5

x = np.arange(0, n + 1)
pmf_values = binom.pmf(x, n, p)
cdf_values = binom.cdf(x, n, p)

plt.figure(figsize=(12, 5))

plt.subplot(1, 2, 1)
plt.stem(x, pmf_values, basefmt=" ")
plt.title('PMF of 100 Coin Tosses')
plt.xlabel('Number of Heads')
plt.ylabel('Probability')

plt.subplot(1, 2, 2)
plt.plot(x, cdf_values, 'b-')
plt.title('CDF of 100 Coin Tosses')
plt.xlabel('Number of Heads')
plt.ylabel('Cumulative Probability')

plt.tight_layout()
plt.show()
```

5 Results

The resulting plots clearly demonstrate the Binomial distribution's characteristics:

- The PMF peaks around 50 heads, showing the most probable outcome.
- The CDF increases gradually and approaches 1 as the number of heads approaches 100.

6 Conclusion

This experiment successfully visualized the behavior of a large Binomial distribution using Python. As expected, the PMF is symmetric and centered around 50, while the CDF rises steeply in that region. This experiment validates the theoretical understanding of the Binomial distribution and its real-world simulation through code.

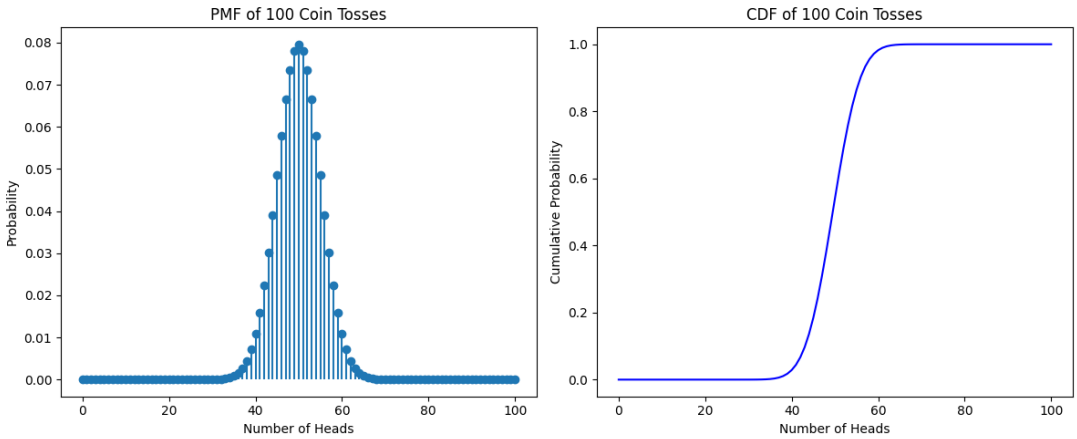

Figure 1: PMF and CDF of 100 Coin Tosses