**深 圳 大 学 实 验 报 告**

**课程名称：­ 概率论与数理统计**

**实验项目名称： Axiom of Probability in Python**

**学院： 电子与信息工程学院**

**专业： 电子信息工程**

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**教务处制**

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| Aim of Experiment:   1. Understand the meaning of frequency and be able to calculate it. Utilize random simulation methods in Python to estimate the frequency of getting heads in coin tosses. Compare and comprehend the distinctions between frequency and probability. 2. Master the fundamental operations and laws of sets, such as De Morgan's laws, and so on. 3. 理解频率的含义并会计算，使用python中随机模拟的方法来估计硬币抛掷正面朝上的频率。比较并理解频率和概率的区别。   2、掌握集合的基本运算和定律，如德摩根定律等。 |
| Experiment Content:   1. `seq\_sum(n)` generates a random coin toss sequence and calculates the number of heads that appear. 2. `estimate\_prob(n, k1, k2, m)` estimates the probability of the number of heads appearing in a coin toss sequence, using a certain number of trials. 3. `calc\_prob(n, k1, k2)`, `evaluate(n, q1, q2, m, r=100)`, `test\_report\_assert(n, q1, q2, m, r=100)` are auxiliary functions for calculating the true probability and are used to test the accuracy of the code. 4. `complement\_of\_union(A, B, U)` calculates and outputs the union of the given sets A and B, as well as its complement. 5. `intersection\_of\_complements(A, B, U)` calculates and outputs the intersection of complements of the given sets A and B. 6. `union(A, B)` calculates the union of the given sets A and B and returns its size. 7. `inclusion\_exclusion(A, B)` calculates the intersection and union sizes of the given sets A, B, and C and uses the inclusion-exclusion principle for calculation. 8. `union3(A, B, C)` calculates the union of the given three sets A, B, and C and returns its size. 9. `inclusion\_exclusion3(A, B, C)` calculates the intersection and union sizes of the given sets A, B, and C. 10. seq\_sum(n)生成随机的硬币投掷序列，并计算正面出现的次数。 11. estimate\_prob(n, k1, k2, m)估算硬币投掷序列中正面出现次数的概率，使用包含一定次数的试验。 12. calc\_prob(n, k1, k2)，evaluate(n, q1, q2, m, r=100)，   test\_report\_assert(n, q1, q2, m, r=100)计算真实概率的辅助函数，用于测试代码的准确性。   1. complement\_of\_union(A, B, U)计算并输出给定集合 A 和 B 的并集以及它的补集。 2. intersection\_of\_complements(A, B, U)计算并输出给定集合 A 和 B 的补集的交集。 3. union(A, B)计算给定集合 A 和 B 的并集并返回其大小。 4. inclusion\_exclusion(A, B)计算给定集合 A、B 和 C 的交集和并集的大小，并使用包含-排除原理计算。 5. union3(A, B, C)计算给定三个集合 A 、 B和C 的并集并返回其大小。 6. inclusion\_exclusion3(A, B, C)计算给定集合 A、B 和 C 的交集和并集的大小。 |
| Experiment Process：  1. Random Coin Toss Simulation:  - Write the `seq\_sum` function to generate a random coin toss sequence for a specified number of times and calculate the number of heads that appear.  - Perform multiple simulation experiments by calling the `seq\_sum` function and count the occurrences of heads.  - Use assert statements to verify if the results of the simulation experiments are within the expected range, checking the correctness of the function.  2. Probability Estimation:  - Write the `estimate\_prob` function to estimate the probability of heads appearing within a specified range using the `seq\_sum` function from Experiment 1.  - Conduct multiple estimation experiments by calling the `estimate\_prob` function and obtain probability estimates.  - Use assert statements to validate if the probability estimates fall within the expected range, checking the accuracy of the function.  3. Calculating True Probabilities:  - Develop auxiliary functions `calc\_prob` and `evaluate` to calculate actual probabilities and gather statistical information from experimental data.  - Run the `evaluate` function with different parameter settings to obtain comparisons between estimated values and actual probability values.  - Use assert statements to verify if the differences between estimated values and actual probability values are within a reasonable range.  4. Set Operations:  - Write the `complement\_of\_union` function to calculate the union of given sets A and B and its complement.  - Develop the `intersection\_of\_complements` function to compute the intersection of complements of sets A and B.  - Call these two functions and use assert statements to validate the correctness of the calculation results.  5. Set Sizes:  - Create the `union` function to calculate the union of given sets A and B and return its size.  - Implement the `intersection` function to compute the intersection of given sets A and B and return its size.  - Call these two functions and use assert statements to verify the correctness of the calculation results.  6. Inclusion-Exclusion Principle:  - Write the `union3` function to calculate the union of given sets A, B, and C and return its size.  - Develop the `inclusion\_exclusion3` function to use the inclusion-exclusion principle to calculate the intersection and union sizes of sets A, B, and C.  - Call these two functions and use assert statements to validate the correctness of the calculation results.  1、随机硬币投掷模拟：  编写 seq\_sum 函数，生成指定次数的随机硬币投掷序列，并计算正面出现的次数。  调用 seq\_sum 函数多次进行模拟实验，统计正面出现的次数。  使用 assert 语句验证模拟实验的结果是否在预期范围内，以检查函数的正确性。  2、估算概率：  编写 estimate\_prob 函数，利用实验一中的 seq\_sum 函数来估算指定范围内正面出现的概率。  调用 estimate\_prob 函数多次进行估算实验，获取概率估计值。  使用 assert 语句验证概率估计值是否在预期范围内，以检查函数的准确性。  3、计算真实概率：  编写用于计算真实概率的辅助函数 calc\_prob 和 evaluate，用于计算实际的概率和统计实验数据的统计信息。  在不同参数设置下，运行 evaluate 函数，获取实际概率值和估算值的比较结果。  使用 assert 语句验证估算值与真实概率值的差异是否在合理范围内。  4、集合操作：  编写 complement\_of\_union 函数，计算给定集合 A 和 B 的并集以及并集的补集。  编写 intersection\_of\_complements 函数，计算给定集合 A 和 B 的补集的交集。  调用这两个函数并使用 assert 语句验证计算结果是否正确。  5、集合大小：  编写 union 函数，计算给定集合 A 和 B 的并集并返回其大小。  编写 intersection 函数，计算给定集合 A 和 B 的交集并返回其大小。  调用这两个函数并使用 assert 语句验证计算结果是否正确。  6、包含-排除原理：  编写 union3 函数，计算给定集合 A、B 和 C 的并集并返回其大小。  编写 inclusion\_exclusion3 函数，使用包含-排除原理计算给定集合 A、B 和 C 的交集和并集的大小。  调用这两个函数并使用 assert 语句验证计算结果是否正确。 |
| Data Logging and Processing:  1. Random Coin Toss Simulation:  - In the `seq\_sum` function, record the results of each coin toss (heads or tails).  - During the simulation experiments, keep track of the number of times heads appear in each experiment.  2. Probability Estimation:  - Inside the `estimate\_prob` function, record the number of times heads appear after each call to the `seq\_sum` function.  - In multiple estimation experiments, record the results of each estimation.  3. Calculating True Probabilities:  - In the `evaluate` function, record the true probabilities and estimated probabilities for each experiment.  - Aggregate statistical information such as medians and standard deviations from multiple estimation experiments.  4. Set Operations:  - Within the `complement\_of\_union` function, record the computed union and its complement.  - In the `intersection\_of\_complements` function, record the computed intersection of complements.  5. Set Sizes:  - In the `union` function, record the computed union and its size.  - In the `intersection` function, record the computed intersection and its size.  6. Inclusion-Exclusion Principle:  - Inside the `union3` function, record the computed union of the three sets and its size.  - In the `inclusion\_exclusion3` function, record the calculated intersection and union sizes of the three sets.  1、随机硬币投掷模拟：  在 seq\_sum 函数中，记录每次硬币投掷的结果（正面或反面）。  在模拟实验中，记录每次实验的正面出现次数。  2、估算概率：  在 estimate\_prob 函数中，记录每次调用 seq\_sum 函数后的正面出现次数。  在多次估算实验中，记录每次估算的结果。  3、计算真实概率：  在 evaluate 函数中，记录每次实验的真实概率和估算概率。  统计多次估算实验的结果，计算中位数、标准差等统计信息。  4、集合操作：  在 complement\_of\_union 函数中，记录计算得到的并集和补集。  在 intersection\_of\_complements 函数中，记录计算得到的交集和补集的交集。  5、集合大小：  在 union 函数中，记录计算得到的并集和其大小。  在 intersection 函数中，记录计算得到的交集和其大小。  6、包含-排除原理：  在 union3 函数中，记录计算得到的三个集合的并集和其大小。  在 inclusion\_exclusion3 函数中，记录计算得到的交集和并集的大小。 |
| Experimental Results and Analysis:  1. Random Coin Toss Simulation:  Through extensive simulations of coin tosses, the number of occurrences of heads was obtained. For example, an estimation was conducted for the number of times heads appeared in 100 coin tosses, resulting in approximately 49 occurrences.  Analysis: The experimental results closely align with the theoretical probability of a coin flip (0.5). This indicates that the simulated coin tosses are random, and over a large number of experiments, the occurrences of heads and tails are roughly equal.  2. Probability Estimation:  By invoking the `seq\_sum` function multiple times, probabilities under specified conditions were estimated. For instance, the probability of the number of times heads appeared in 100 coin tosses falling between 45 and 55 was estimated to be approximately 0.686.  Analysis: Experimental results demonstrate that, over a large number of trials, the estimated probabilities under specified conditions closely approximate theoretical probabilities. This validates the effectiveness of the estimation method.  3. Calculating True Probabilities:  True probability values were obtained using mathematical methods for calculating probabilities and were compared with estimated probabilities.  Analysis: Experimental results indicate that, across multiple estimations, the estimated probabilities closely match the true probabilities. This suggests the accuracy of the estimation method, which can be employed for approximating the probabilities of complex events.  4. Set Operations:  Set operations were executed to obtain the results of unions and intersections, as well as their respective sizes.  Analysis: Experimental results confirm that the functions implementing set operations are correct. They accurately compute unions and intersections while providing the correct sizes.  5. Set Sizes:  By invoking functions for set operations, the results of unions and intersections, along with their sizes, were obtained.  Analysis: Experimental results demonstrate that the functions for set operations correctly calculate the sizes of unions and intersections, aligning with the expected outcomes.  6. Inclusion-Exclusion Principle:  The Inclusion-Exclusion principle was applied to calculate the size of unions.  Analysis: Experimental results reveal that the Inclusion-Exclusion principle was correctly employed to compute the size of unions, yielding results consistent with direct calculations.  1、随机硬币投掷模拟：  通过大量的硬币投掷模拟，得到了正面出现的次数。例如，估算了100次硬币投掷中正面出现的次数，结果约为49次。  分析：实验结果与硬币的理论概率（0.5）相近，这表明模拟的硬币投掷是随机的，并且在大量实验中，正面和反面出现的次数大致相等。  2、估算概率：  通过调用 seq\_sum 函数多次，估算了指定条件下的概率。例如，估算了100次硬币投掷中正面出现次数在45到55之间的概率，结果约为0.686。  分析：实验结果表明，在大量试验中，指定条件下的概率估算接近于理论概率，这证明了估算方法的有效性。  3、计算真实概率：  通过使用计算概率的数学方法，得到了真实的概率值。然后与估算的概率进行比较。  分析：实验结果显示，在多次估算中，估算的概率与真实概率非常接近。这表明估算方法是准确的，并且可以用于近似计算复杂事件的概率。  4、集合操作：  通过执行集合操作，得到了并集和交集的结果，以及它们的大小。  分析：实验结果表明，集合操作的函数实现是正确的，它们能够正确地计算并集和交集，并给出了正确的大小。  5、集合大小：  通过调用集合操作的函数，得到了并集和交集的结果以及它们的大小。  分析：实验结果表明，集合操作函数能够正确计算并集和交集的大小，与预期的结果一致。  6、包含-排除原理：  通过应用包含-排除原理，计算了并集的大小。  分析：实验结果显示，包含-排除原理正确地用于计算并集的大小，结果与直接计算的结果一致。 |
| 指导教师批阅意见：  成绩评定：  指导教师签字：  年 月 日 |
| 备注： |