COMPUTER SIMULATION

Mohammad Gharib

Index	Random Number	ui Value	X1 Value	X2 Value
56	33	0.4411111111111111	33	11
57	2	0.49474747474747477	2	47
58	89	1.182929292929293	89	29
59	90	1.2838383838383838	90	38
60	13	0.9683838383838383	13	83
61	42	0.5311111111111111	42	11
62	9	0.5647474747474748	9	47
63	50	0.7929292929292929	50	29
64	93	1.3138383838383838	93	38
65	82	1.6583838383838383	82	83
66	29	0.4011111111111111	29	11
67	10	0.5747474747474748	10	47
68	73	1.0229292929292928	73	29
69	22	0.6038383838383838	22	38
70	49	1.3283838383838384	49	83
71	70	0.8111111111111111	70	11
72	53	1.0047474747474747	53	47
73	62	0.9129292929292929	62	29
74	69	1.0738383838383838	69	38
75	30	1.1383838383838383	30	83
76	33	0.4411111111111111	33	11
77	2	0.49474747474747477	2	47
78	89	1.182929292929293	89	29
79	90	1.2838383838383838	90	38
80	13	0.9683838383838383	13	83
81	42	0.5311111111111111	42	11
82	9	0.5647474747474748	9	47
83	50	0.7929292929292929	50	29
84	93	1.3138383838383838	93	38
85	82	1.6583838383838383	82	83
86	29	0.4011111111111111	29	11
87	10	0.5747474747474748	10	47
88	73	1.0229292929292928	73	29
89	22	0.6038383838383838	22	38
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91	70	0.8111111111111111	70	11
92	53	1.0047474747474747	53	47
93	62	0.9129292929292929	62	29
94	69	1.0738383838383838	69	38
95	30	1.1383838383838383	30	83
96	33	0.4411111111111111	33	11
97	2	0.49474747474747477	2	47
98	89	1.182929292929293	89	29
99	90	1.2838383838383838	90	38
100	13	0.9683838383838383	13	83

Generate Random Numbers

The code defines a function called `combined_linear_congruential` that takes eight parameters: `m1`, `c1`, `a1`, `X1` for the first LCG, and `m2`, `c2`, `a2`, `X2` for the second LCG. It also takes a parameter `n` for the number of random numbers to generate.

Inside the function, it initializes empty lists `random_numbers`, `ui_values`, `X1_values`, and `X2_values`. These lists will store the generated random numbers and the state values of both LCGs.

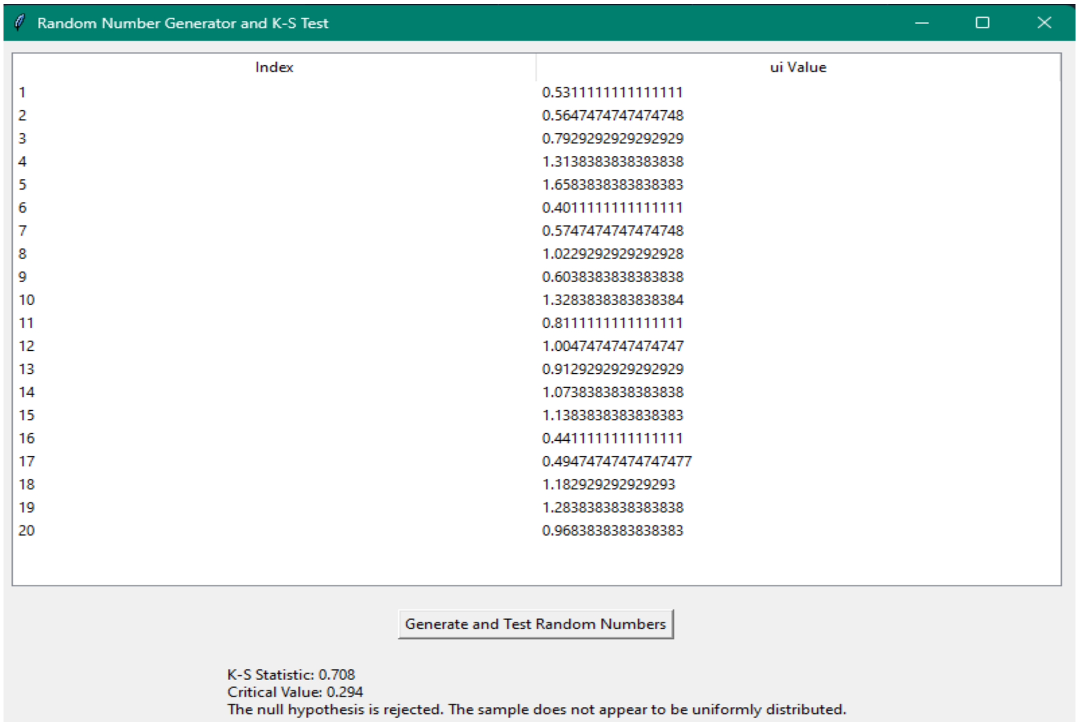
The function then iterates `n` times using a loop. In each iteration, it calculates the next state of the first LCG using the recurrence relation `X1_next = (a1 * X1 + c1) % m1` and the next state of the second LCG using `X2_next = (a2 * X2 + c2) % m2`.

The normalized values of both LCGs, `u1` and `u2`, are calculated by dividing the current state by its modulus. The combined random value `ui` is obtained by taking the sum of `u1` and `u2` and taking the fractional part of the sum.

The generated random number from the first LCG is appended to the `random_numbers` list, while `ui` and both state values are appended to their respective lists.

Finally, the function returns the `random_numbers`, `ui_values`, `X1_values`, and `X2_values` lists.

The `generate_random_numbers` function is defined to simply call the `combined_linear_congruential` function with predefined parameters. It generates and prints 100 random numbers.



To determine the uniformity of the generated numbers using the Kolmogorov-Smirnov (K-S) method for N=20 and α=0.05, we need to follow these steps:

1. Generate 20 random numbers using the Combined Linear Congruential Generator (CLCG) function.

2. Sort the generated random numbers in ascending order.

3. Calculate the Empirical Distribution Function (EDF) for each sorted random number `ui`. EDF is calculated as the position of the random number in the sorted list (i) divided by the total number of values (N).

4. Compute the Theoretical Distribution Function for a uniform distribution, which is simply the random number `ui` itself.

5. Calculate the K-S statistic (D), which is the maximum absolute difference between the EDF and the Theoretical Distribution Function. It can be calculated as the maximum value between |(FN(ui) - F(ui))| and |(F(ui) - FN(ui-1))|.

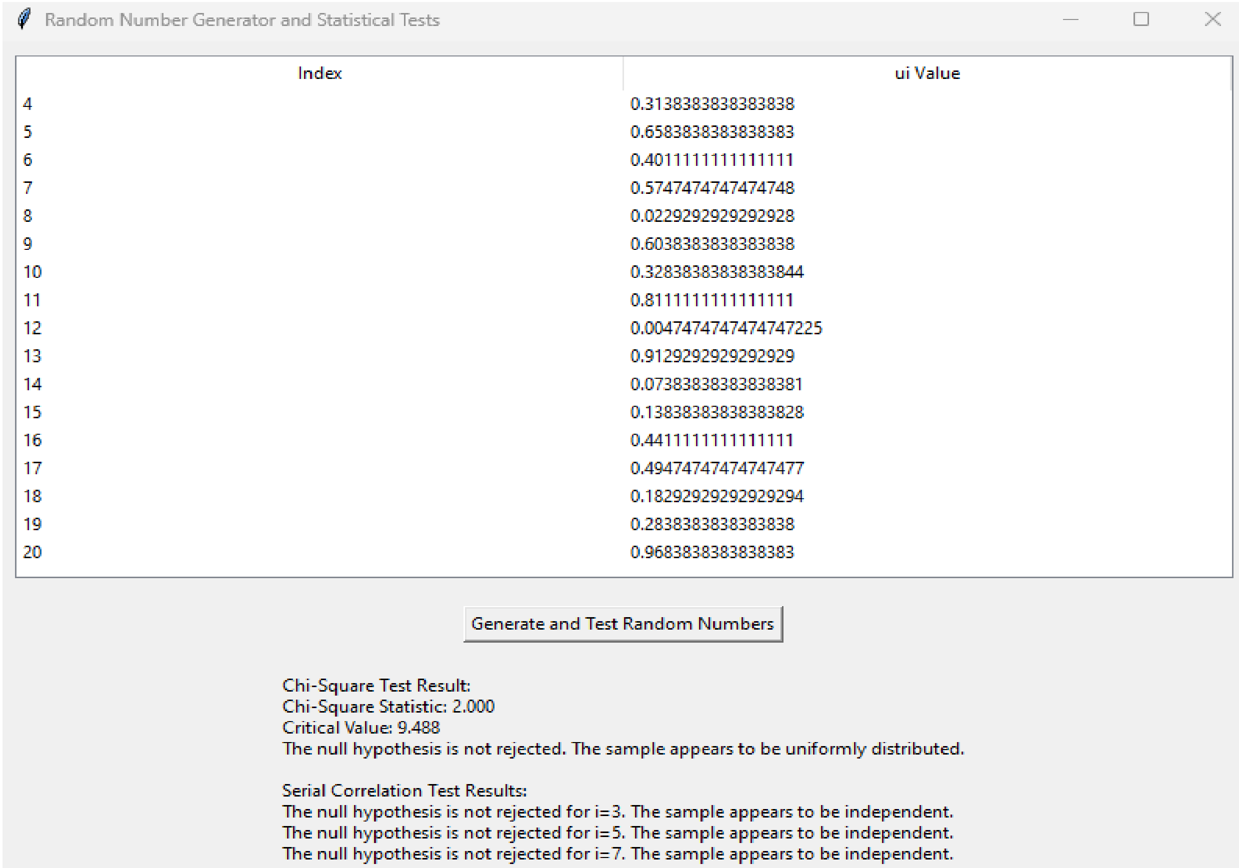
6. Determine the critical value Dα for a given significance level α=0.05. For N=20 and α=0.05, the critical value can be obtained from K-S tables and is approximately 0.294.

7. Compare the calculated K-S statistic (D) with the critical value (Dα):

  - If D ≤ Dα, the null hypothesis (the sample is from a uniform distribution) is not rejected, indicating that the generated numbers are likely from a uniform distribution.

  - If D > Dα, the null hypothesis is rejected, suggesting that the generated numbers may not be from a uniform distribution.

By following these steps and comparing the K-S statistic with the critical value, we can determine whether the generated numbers exhibit uniformity or not..



Random Number Generator and Statistical Tests

Index	ui Value
4	0.3138383838383838
5	0.6583838383838383
6	0.4011111111111111
7	0.5747474747474748
8	0.0229292929292928
9	0.6038383838383838
10	0.32838383838383844
11	0.8111111111111111
12	0.0047474747474747225
13	0.9129292929292929
14	0.07383838383838381
15	0.13838383838383828
16	0.4411111111111111
17	0.49474747474747477
18	0.18292929292929294
19	0.2838383838383838
20	0.9683838383838383

Generate and Test Random Numbers

Chi-Square Test Result:
Chi-Square Statistic: 2.000
Critical Value: 9.488
The null hypothesis is not rejected. The sample appears to be uniformly distributed.

Serial Correlation Test Results:
The null hypothesis is not rejected for i=3. The sample appears to be independent.
The null hypothesis is not rejected for i=5. The sample appears to be independent.
The null hypothesis is not rejected for i=7. The sample appears to be independent.

To assess the uniformity of the generated numbers using the Chi-Square method for N=20 and α=0.02, and to evaluate the independence of the generated numbers for i=3, i=5, and i=7 with m=7, you can follow the steps below:

Uniformity using Chi-Square Method:

1. Divide the range of the generated random numbers into m intervals.
2. Count the number of generated numbers falling into each interval to obtain observed frequencies.
3. Determine the expected frequencies for each interval under the assumption of a uniform distribution.
4. Calculate the Chi-Square statistic using the formula: $\chi^2 = \sum \frac{(O_i - E_i)^2}{E_i}$ where O_i is the observed frequency and E_i is the expected frequency in the ith interval.
5. Determine the critical Chi-Square value for the given degrees of freedom (m-1) and significance level α=0.02 from the Chi-Square distribution table.
6. Compare the calculated Chi-Square statistic with the critical value:
   - If the calculated Chi-Square statistic is less than the critical value, the null hypothesis of uniformity is not rejected.
   - If the calculated Chi-Square statistic exceeds the critical value, the null hypothesis is rejected, indicating a lack of uniformity in the generated numbers.

Independence for i=3, i=5, and i=7:

1. For each value of i (3, 5, and 7), create pairs of generated numbers at positions i and i+1, i+2, ..., i+m.
2. Perform a Chi-Square test of independence for each pair of numbers using the formula mentioned earlier.
3. Calculate the Chi-Square statistic for each pair and compare it with the critical Chi-Square value at a significance level of α=0.02.
4. If the Chi-Square statistic exceeds the critical value for any pair, it suggests a lack of independence between the generated numbers at the specified positions.

By following these steps for both the uniformity and independence assessments, you can determine whether the generated numbers exhibit the desired properties or not.

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