Project 0: Coin Tossing Experiment

EE 511 – Section: Tuesday 5 pm
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A)

1. Problem Statement

Simulate tossing a coin 100 times and record,
   i.   the number of heads N_H
   ii. the length of the longest run of heads L_H

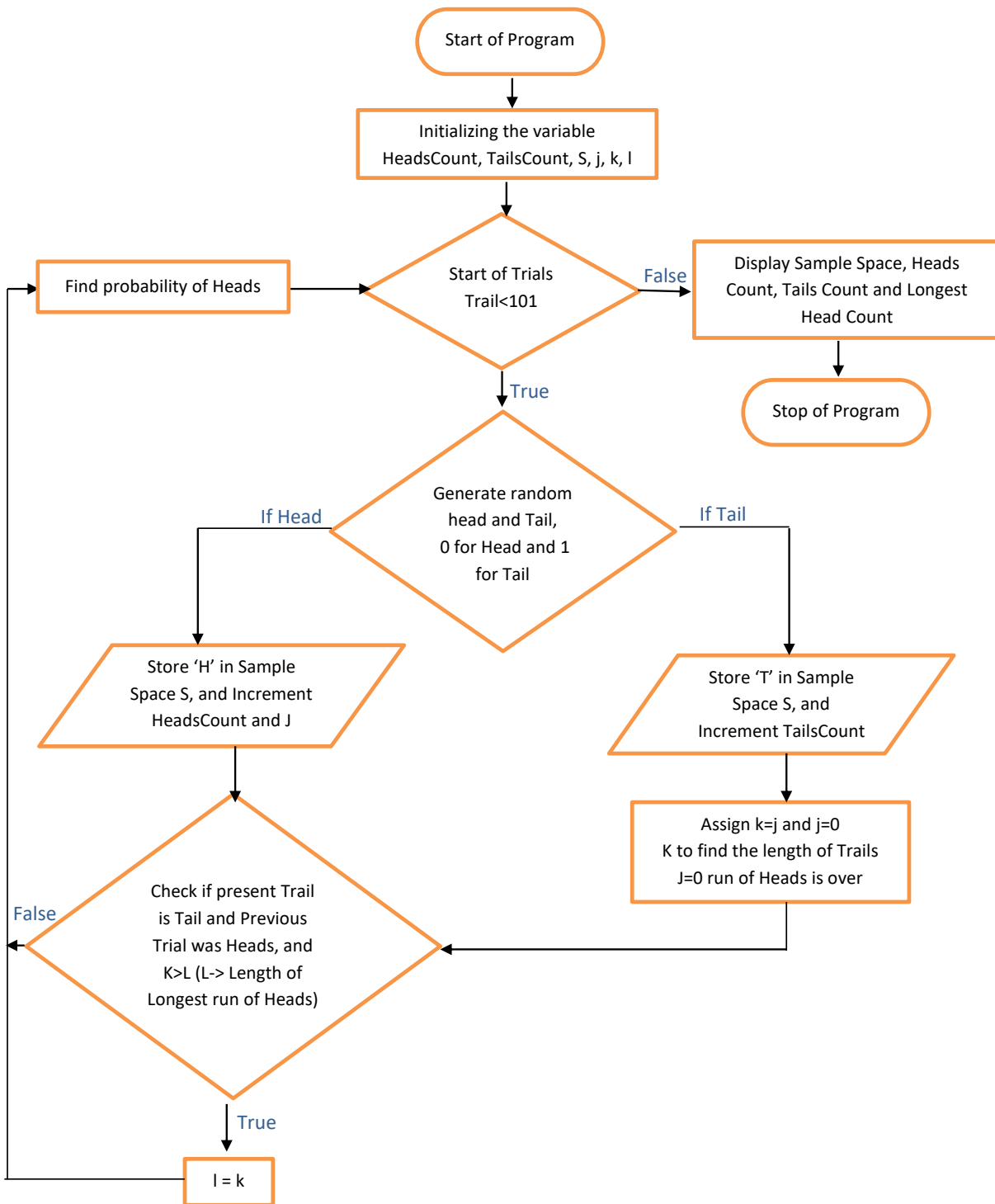## 2. Theoretical Exploration or Analysis –

When we toss a coin, occurrence of Head or Tail is a random event. Thus, when we toss the coin 100 times the number of head count is random, but the probability of occurrence of heads tends to become 0.5 as we increase the number of Trials.

3. Simulation Methodology
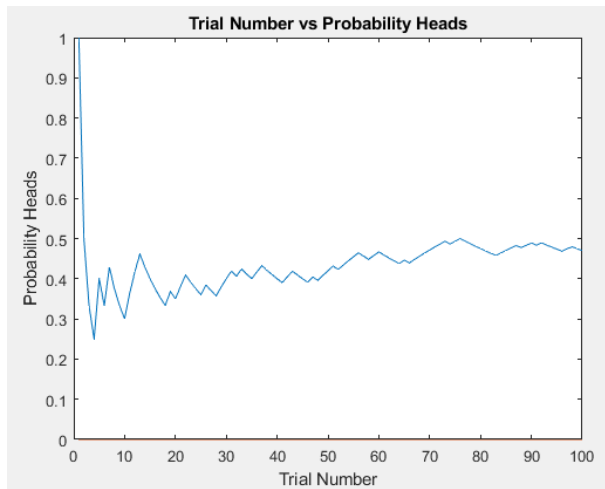
Simulation steps:
   1. Initialize the number of Trials
   2. Start the Trial
   3. Generate random number, 0 for Head and 1 for Tail
   4. Store Head or Tail in the Sample Space, and Count the Number of Heads
   5. Check if run of Heads length is the Longest run of Heads
   6. Find the probability of Occurrence of Head for each Trial
   7. After 100 Trials are complete, Display the Head Count, Sample Space, Length of Longest run of heads, and Graph showing Probability of occurrence of Head
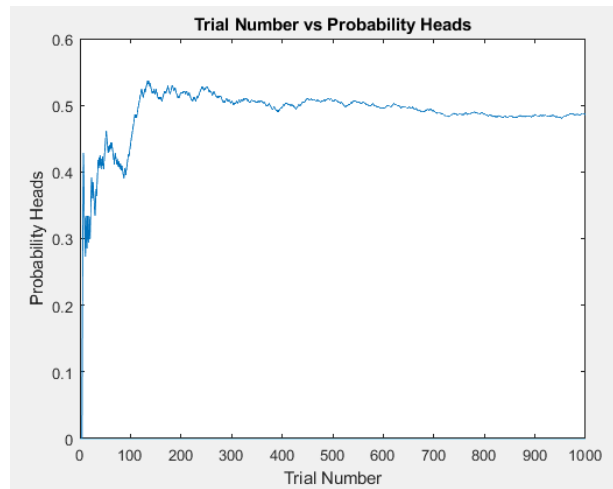
Flowchart:

Start of Program

Initializing the variable
HeadsCount, TailsCount, S, j, k, l

Find probability of Heads

Start of Trials
Trail<101

False → Display Sample Space, Heads Count, Tails Count and Longest Head Count

Stop of Program

True

Generate random head and Tail, 0 for Head and 1 for Tail

If Head → Store 'H' in Sample Space S, and Increment HeadsCount and J

If Tail → Store 'T' in Sample Space S, and Increment TailsCount

Assign k=j and j=0
K to find the length of Trails
J=0 run of Heads is over

Check if present Trail is Tail and Previous Trial was Heads, and K>L (L-> Length of Longest run of Heads)

False

True

l = k

4. Experiments and Results

Number of Trials: 100   Number of Trials: 1000

SL.No.	Head Count	Tail Count	Length of Longest run of Heads
1.	50	50	5
2.	48	52	9
3.	47	53	6
4.	43	57	4
5.	45	55	8

Discussion of Results:

As we can see in the above results occurrence of Heads and Tails in the coin toss is a random event, and the probability of occurrence of Heads tends to 0.5 as we increase the number of Trials.

5. References

i.   https://www.tutorialspoint.com/matlab/
ii. https://www.mathworks.com/help/matlab/

6. Source Code

```matlab
% start of programming code
clear all;       % clear and close matlab desktop,workspace
close all;
clc;
S={};            % Array of Sample Space for 100 Coin Toss
HeadsCount=0;    % Number of Heads Count
TailsCount=0;    % Number of Tails Count
trial=100;       % Intializing number of Coin Toss Trials
j= 0;            % Assigning value to j
k=0;             % Assigning value to k
l=0;             % Assigning value to l
pro_h=zeros(trial);
for i=1:trial            % Start of For loop
    rand = randi([0,1]);  % Random Head and Tails generating 0 for Head,
                          1 for Tail
    if rand == 0          % If Head happens
        S{i} = 'H';       % Store 'H' character in string array S
        HeadsCount = HeadsCount+1;  % Increase Head count by 1
        j=j+1;                      % Increase j
    elseif rand == 1      % Else if Tail happens
        S{i} = 'T';       % Store 'T' character in string array S
        TailsCount = TailsCount+1;  % Increase Tail count by 1
        k=j;              % Assign value of j to k | k variable is used to
                            find the length of run of heads
        j=0;              % Assign 0 to j variable which means run of heads
                            is completed
    end                   % End of If loop, counted heads and tails
    if(j == 0 && k ~= 0)  % if j is 0 i.e if trial is Tails, and k not equal
                            to 0 i.e length of run of heads
        if( k > l )       % if k greater than l | l variable is used to find
                            the length of longest run of heads
            l = k;        % assign value of k to l
        end
    end             % End of if loop, Found the Length of Longest run of heads
pro_h(i) = heads/i;  % Probability of Total Head/Total Outcomes
end                      % End of For loop
disp(S);                 % Display Sample Space
fprintf('Heads Count: %d\n',HeadsCount);     % print the count of Heads
fprintf('Tails Count: %d\n',TailsCount);     % print the count of Tails
fprintf('Longest Head Count: %d\n',l); % print the Longest run of Heads
plot(1:trial,pro_h)     % Plotting bar graph y in x axis and x in y axis
xlabel('Trial Number')       % X axis Label
ylabel('Probability Heads')      % Y axis Label
title ('Trial Number vs Probability Heads') % Title of the graph
```

B)

1. Problem Statement

Simulate repeatedly tossing a coin and record the number of tosses until: the first head occurs S1; the first time 2 heads in sequence occurs S2; the first time 3 heads in sequence occurs S3; the first time 4 heads in sequence occurs S4.

2. Theoretical Exploration or Analysis:

We toss the coin repeatedly and record the number of toss. S1, S2, S3, S4 to be noted as in the following example.

e.g. if the observed sequence is: TTHTHTHHTTHTHHHH
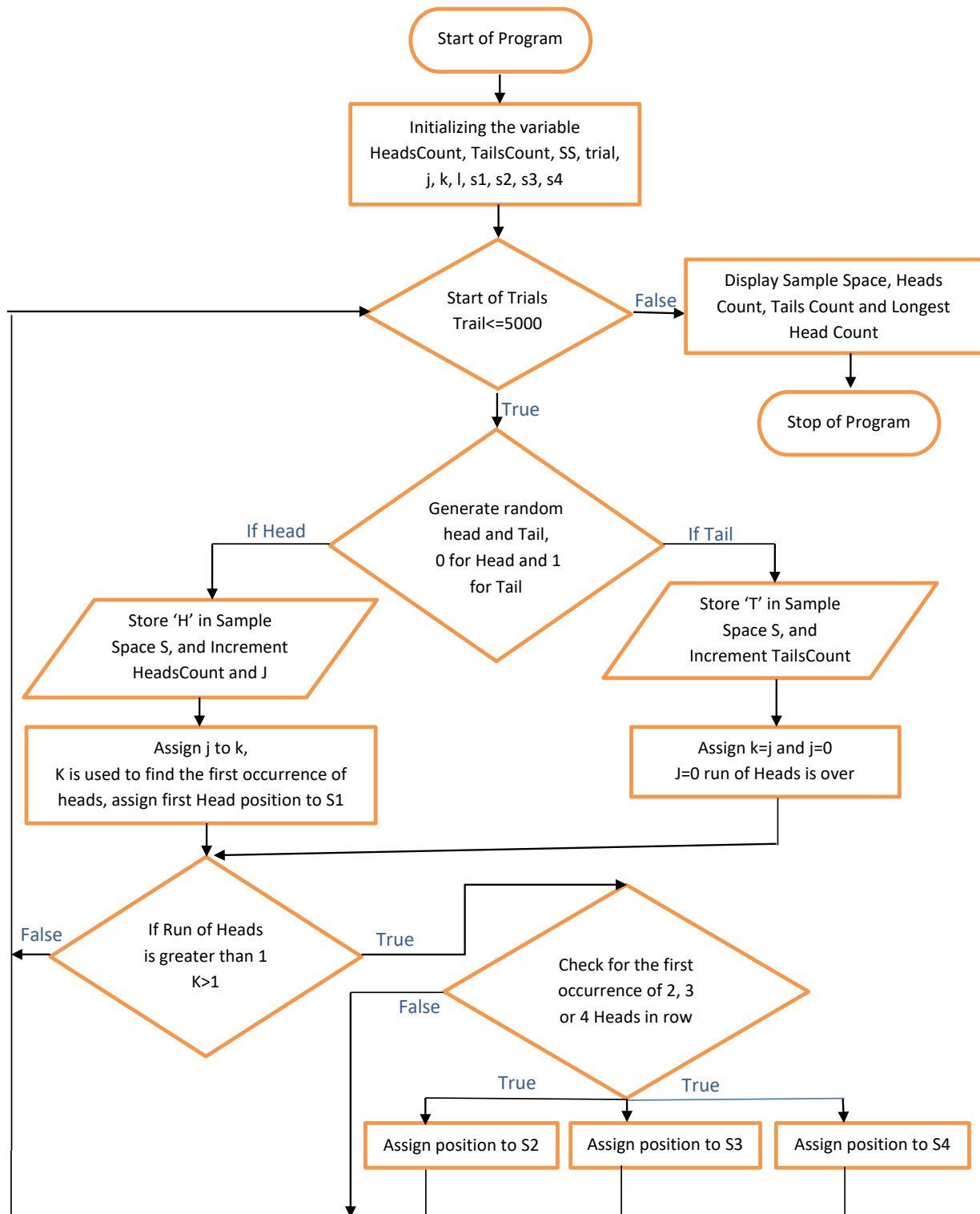
you would record S1 = 3,S2 = 8,S3 = 15,S4 = 16

When we toss coin for 5000 sample, Frequency distribution of Heads and Tails is recorded.

3. Simulation Methodology

Simulation steps:
1. Initialize the number of Trials
2. Start the Trial
3. Generate random number, 0 for Head and 1 for Tail
4. Store Head or Tail in the Sample Space, and Count the Number of Heads
5. Assign the First Head position to S1
6. Check if run Head sequence is greater than 1
7. Assign the the first time 2 heads in sequence occurs S2; the first time 3 heads in sequence occurs S3; the first time 4 heads in sequence occurs S4
8. Display the Head Count, Sample Space, Length of Longest run of heads, and Graph showing Probability of occurrence

Flowchart:

```
                          ╭─────────────────╮
                          │  Start of Program │
                          ╰─────────────────╯
                                   │
                          ┌─────────────────┐
                          │ Initializing the variable │
                          │ HeadsCount, TailsCount, SS, trial, │
                          │ j, k, l, s1, s2, s3, s4 │
                          └─────────────────┘
                                   │
                                                    ┌─────────────────┐
                          ◇─────────────◇   False   │ Display Sample Space, Heads │
                          │ Start of Trials │──────→ │ Count, Tails Count and Longest │
                          │  Trail<=5000   │         │    Head Count    │
                          ◇─────────────◇            └─────────────────┘
                                   │                          │
                                 True              ╭─────────────────╮
                                   │               │  Stop of Program │
                                                   ╰─────────────────╯

                          ◇─────────────◇
            If Head        │ Generate random │        If Tail
          ┌────────────────│ head and Tail,  │────────────────┐
          │                │ 0 for Head and 1 │               │
          │                │   for Tail     │                 │
          ▼                ◇─────────────◇                    ▼
    ╱─────────────╲                                    ╱─────────────╲
   │ Store 'H' in Sample │                            │ Store 'T' in Sample │
   │ Space S, and Increment │                         │   Space S, and   │
   │ HeadsCount and J │                               │ Increment TailsCount │
    ╲─────────────╱                                    ╲─────────────╱
          │                                                   │
   ┌─────────────┐                                    ┌─────────────┐
   │ Assign j to k,  │                                │ Assign k=j and j=0 │
   │ K is used to find the first │                    │ J=0 run of Heads is over │
   │ occurrence of heads, assign │                    └─────────────┘
   │ first Head position to S1 │
   └─────────────┘
```

4. Experiments and Results

SL.No.	Sample Space	Head Count	Tail Count	S1	S2	S3	S4
1.	5000	2480	2520	2	3	4	5
2.	5000	2529	2471	1	2	21	46
3.	5000	2486	2514	2	3	4	51
4.	5000	2478	2522	1	2	31	32
5.	5000	2502	2498	1	2	3	4

Discussion of results: As we see the results, the S1, S2, S3, S4 has been successful recorded for repeated tossing samples, and the frequency distribution for 5000 is also recorded.

5. References

i.   https://www.tutorialspoint.com/matlab/
ii. https://www.mathworks.com/help/matlab/

6. Source Code

```
%start of programming code
clear all;                % clear and close MATLAB desktop, workspace
close all;
SS={};                    % Array of Sample Space for 100 Coin Toss
HeadsCount=0;             % Number of Heads Count
TailsCount=0;             % Number of Tails Count
j=0;  k=0; l=0;  trial=0;      % Assigning value to j, k, l
s=0; s1=0; s2=0; s3=0; s4=0; % Assigning value to s1, s2, s3, s4

while trial~= 0           %start of while loop
trial = input('Enter the number of Trial: '); % get user input
for i=1:trial             % Start of Trail - For Loop
    rand = randi([0,1]);  % Random Head and Tails generating 0 for Head, 1
      s=s+i;                           for Tail
    if rand == 0          % If Head happens
        SS{s} = 'H';       % Store 'H' character in string array S
        heads = heads+1;  % Increase Head count by 1
        j=j+1;            % Increase j
        k=j;              % Assign value of j to k | k variable is used to
                            find the s1, s2,s3,s4
        if(j==1)          % If trial is head
            if(s1==0)     % If Head is the first occurrence
                s1=s;     % assign first position of head occurrence to s1
            end           % end of if
        end
    elseif rand == 1      % Else if Tail happens
        SS{s} = 'T';       % Store 'T' character in string array S
        tails = tails+1;  % Increase Tail count by 1
        k=j;              % Assign value of j to k
        j=0;          % Assign 0 to j variable which means run of heads is over
    end                   % End of If loop | counted head and tail in this loop
    if(k ~= 0)            % check k not equal to 0
        if(k == 2)        % if k=2
          if(s2==0)       % If 2 heads are first occurrence
            s2 = s;       % assign position i to s2
          end
        elseif(k == 3)      % if k=3
            if(s3==0)     % If 3 heads are first occurrence
                s3 = s;   % assign position i to s3
            end
        elseif(k == 4)       % if k=4
            if(s4==0)      % If 4 heads are first occurrence
                s4 = s;    % assign position i to s4
            end
        end
    end
end                           % End of For loop of Trials
end                           % End of While Loop
samplespace=Headscount+Tailscount;
%disp(SS);
fprintf('Frequency Distribution:\n Sample Space: %d\t', samplespace);
fprintf('Heads Count: %d\t',HeadsCount);    % print the count of Heads
fprintf('Tails Count: %d\n',tailsCount);    % print the count of Tails
fprintf('S1: %d\tS2: %d\t S3: %d\tS4: %d\n',s1,s2,s3,s4);
```