James Waterman Homework 0, Summing digits of π, MAT 331, Fall 2023

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Part 1: What is the sum of the first 10,000 digits of pi?

We use vpa to compute N=10000 digits of pi and convert this to a character string y with char. We then let x hold the numerical value of the kth digit, being careful to omit the second character, which is the decimal point. Then t is defined as the sum of all the digits.

```
N=10000;
y=char(vpa(pi,N));
x(1)=str2num(y(1));
y=char(vpa(pi,N));
for k=2:N
x(k)=str2num(y(k+1));
end
t=sum(x)
```

```
t =

      44890
```

This creates a single character string y that is 10,001 characters long (there is an extra character for the decimal point). We then convert this to a string of integers x, remembering to skip the decimal place. The answer to the first part is t= 44890 .

Part 2: If the digits of π are uniformly random in { 0,..., 9}, what would we expect the sum to be? How far apart are the actual and expected sums?

If the digits were uniformly random in \{0,1,\dots,9\} then the average size of a digit would be a = (0+1+\dots +9)/10 = 4.5, and the sum of 10,000 such digits would be 45,000. The difference between this and the actual sum is 45000-44890=110.

Part 3: For 1 <= k <= N , plot the difference between the expected and the actual sum of the first k digits of pi. Do you see any pattern?

To compute the sum of the first k digits of \pi we can either use a loop as follows,

```
c(1)=x(1);
for k=2:N
   c(k)=c(k-1)+x(k);
end
```

or a built-in MATLAB command that does the same thing:

```
d=cumsum(x);
```

We can check that these both give the same list of numbers, by subtracting them and taking the maximum of the absolute value:

```
error = max(abs(c-d))
```

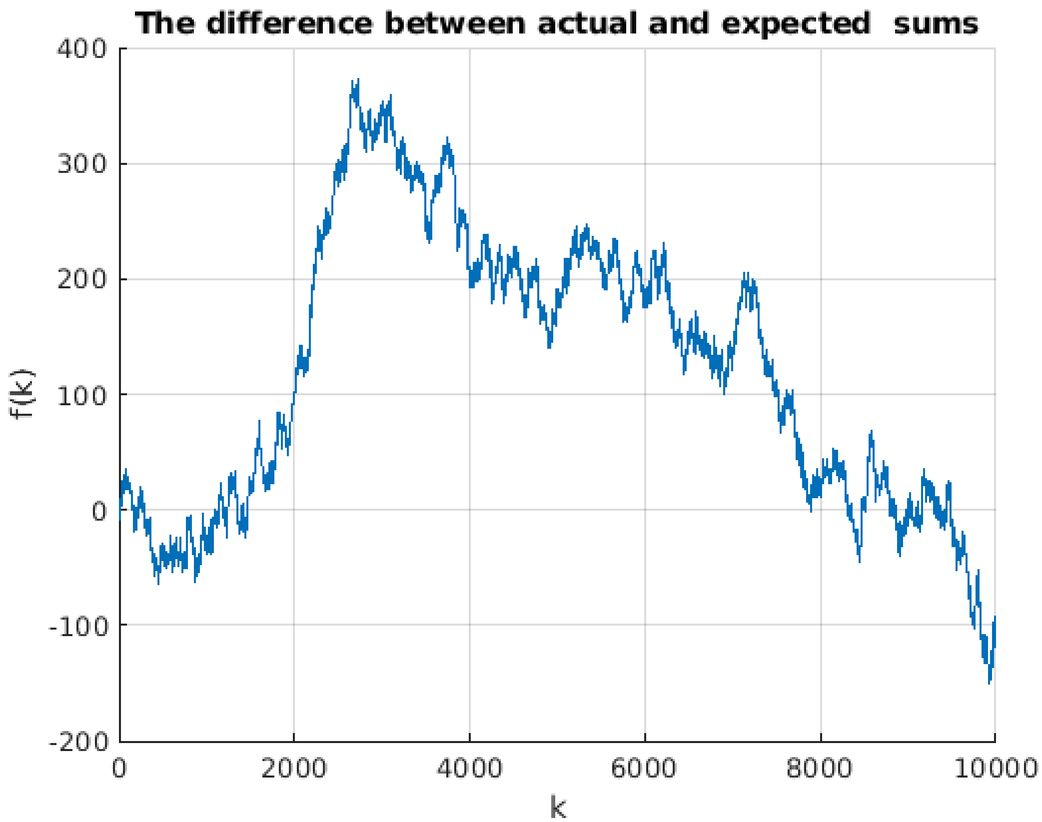
```
error =

     0
```

To plot the difference between c and 4.5 k we use:

```
figure;           %  creates an empty figure window
hold on;          %  tells MATLAB keep all the following features
grid on;          %  creates a grid
title('The difference between actual and expected  sums')
f=c-4.5*[1:N];    % defines difference between actual sum and expected sum
plot(f);          % plots f, default color is blue
xlabel('k');      % puts label on horizontal axis
ylabel('f(k)');   % puts label on vertical axis
```

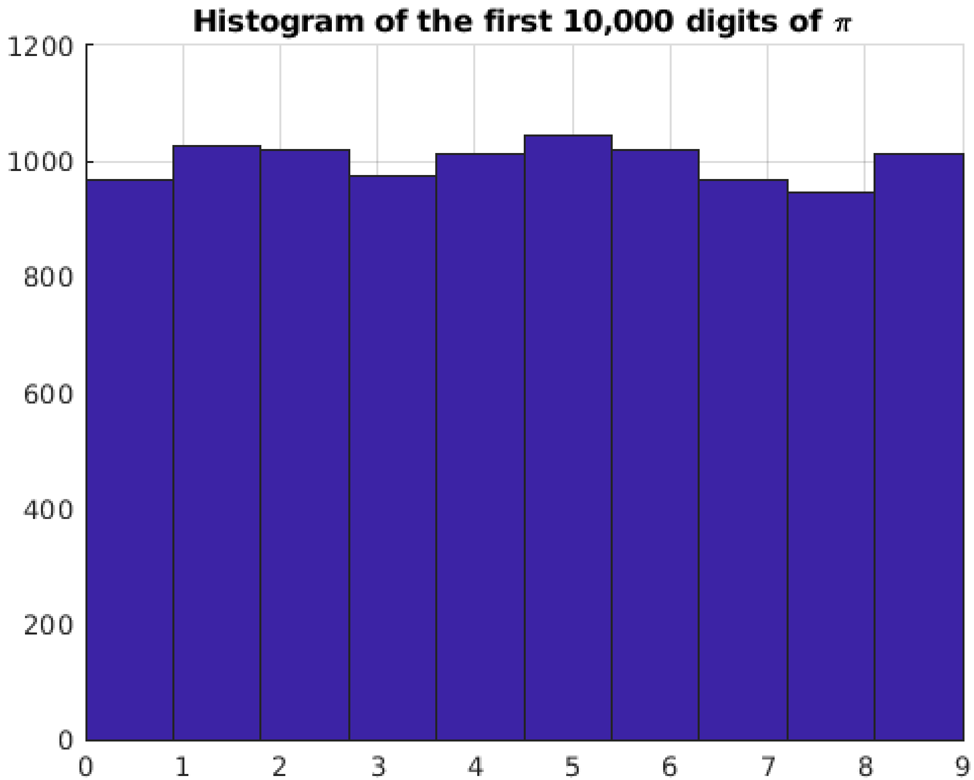
```
% No pattern is apparent. Indeed, the behavior looks pretty random.
```



Part 4: Draw a histogram of how many times each digit is used. Which digit is used the most and which is used the least? How many times are they used?

```
From part (1) the vector x contains the first 10,000 digits of $\pi$.
The command hist(x,n) will plot a histogram of x, i.e., divide the
range of x into n equal intervals and plot a chart showing how many
values of x lie in each bin.  Since x only takes the
10 integer values 0,..,9, if we set n=10, then each digit will be
placed in its own bin.
```

```
figure;
hold on;
grid on;
title('Histogram of the first 10,000 digits of \pi');
hist(x,10);
```



The command h = hist(x,n) does not draw the histogram, but computes the number of values in each bin and puts these values in the n-vector h. The last command creates a 2-column vector such that the first column lists the digits 0-9 and the second lists h, the number of times that digit occurs.

```
h=hist(x,10);
[0:9;h]'
```

```
ans =

           0         968
           1        1026
           2        1021
           3         975
           4        1012
           5        1046
           6        1021
           7         969
           8         948
           9        1014
```

From the values of h, we see that the most used digit is 5 (it occurs 1046 times) and the least used digit is 8 (used 948 times).

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