ENGG1003 - Thursday Week 4

Using random numbers, and reading from spreadsheets

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18 March, 2021

Last compiled: March 18, 2021 5:34pm +11:00

Lecture overview

1. Using random numbers
2. Reading from spreadsheets

- More practice with arrays, iteration, conditional code execution (`if`) and plotting

1) Using random numbers

Recap: generating random numbers

```
In [1]: import numpy as np

In [2]: np.random.randint(1, 6, 4)      # ...4 integers from [1, 6)
Out[2]: array([1, 3, 5, 3])

In [3]: np.random.random(4)          # ...4 floats from [0, 1)
Out[3]: array([ 0.79183276,  0.01398365,  0.04982849,  0.11630963])

In [4]: np.random.uniform(10, 20, 4)    # ...4 floats from [10, 20)
Out[4]: array([ 10.95846078,  17.3971301 ,  19.73964488,  18.14332234])
```

Using `numpy` library:

- random integers
- random floats from $[0, 1)$
- random floats from $[a, b)$

Random integers: simulating coin toss

Example 1

Simulate the toss of a coin N times as follows:

- generate a length-N array of randomly chosen 0s and 1s
  - $0 =$ heads, $1 =$ tails
  - equally likely heads and tails ie: fair coin
- display *expected* number of heads observed
- display *actual* number of heads observed
- test/debug with $N = 100$, then $N = 100,000$

Coin toss simulation

```
1  import numpy as np
2
3  # generate random array of 0s and 1s
4  # 0==heads & 1==tails
5  # N integers from [0,2) ie: 0 or 1
6  N = 100000
7  x = np.random.randint(0, 2, N)
8  print(x)
9
10 headCnt = 0;
11 for i in range(0,N,1):
12     if x[i]==0:
13         headCnt += 1
14
15 print('Expected number of heads: {}'.format(N/2))
16 print('Observed number of heads: {}'.format(headCnt))
```

- Live demo of `headsTails.py`

Random floats: engineering tolerance

Example 2

- steel bolts manufactured with length uniformly distributed between 17 mm and 19 mm
- only bolts with length in range $[17.25, 18.75]$ mm are within tolerance ie: acceptable
- write Python code with random numbers to estimate percentage of bolts which are acceptable
  - demonstrate your code for $N = 10,000$
  - compare with expected percentage of acceptable bolts:

$$100 \times \frac{18.75 - 17.25}{19 - 17} = 75\%$$

Engineering tolerance simulation

```
1  import numpy as np
2
3  # generate random array of N floats in range [17,19)
4  N = 10000
5  x = np.random.uniform(17,19,N)
6  tolLow = 17.25
7  tolHigh = 18.75
8  print(x)
9
10 goodCnt = 0;
11 for i in range(0,N,1):
12     if tolLow <= x[i] <= tolHigh:
13         goodCnt += 1
14
15 print('Percentage of parts within tolerance: {}%'.
       format(100*goodCnt/N))
```

- Live demo of `engTolerance.py`

Random floats: simulate dartboard

Example 3

- a circular dartboard radius 1 m is centred in the middle of a square, side length 2 m
- darts are thrown randomly and land with uniform probability in the square
  - most (but not all) darts land inside the circle

Random floats: simulate dartboard

Example 3

- a circular dartboard radius 1 m is centred in the middle of a square, side length 2 m
- darts are thrown randomly and land with uniform probability in the square
  - most (but not all) darts land inside the circle
- write a Python program which puts a red dot if the dart lands inside (or on the perimeter) of the circle, and a blue dot otherwise
  - Hint: points inside (or on perimeter) of circle satisfy

$$x^2 + y^2 \leq 1$$

- run your program with $N = 100, 1000$ and $10,000$

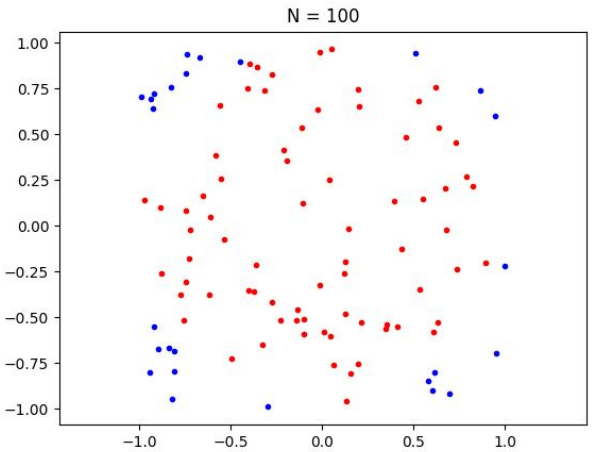
Dartboard simulation: code

```
1  import numpy as np
2  import matplotlib.pyplot as plt
3
4  # generate random array of (x,y) pairs covering
5  # square with edge length 2
6  N = 10000
7  x = np.random.uniform(-1, 1, N)   # N floats from [-1,1)
8  y = np.random.uniform(-1, 1, N)   # N floats from [-1,1)
9
10 for i in range(0,N,1):
11     if x[i]**2 + y[i]**2 <= 1:
12         plt.plot(x[i],y[i],'r.')
13     else:
14         plt.plot(x[i],y[i],'b.')
15
16 plt.axis('equal')   # plot with aspect ratio 1:1
17 plt.title('N = {}'.format(N))
18 plt.show()
```

- Live demo of `dartboard.py`

Dartboard simulation: output

- two length-N arrays of random numbers
  - `x = [x[0],x[1],...,x[N-1]]`
  - `y = [y[0],y[1],...,y[N-1]]`
- `x[i]` $\in [-1, +1)$ for all i, similar for `y[i]`
- position (x_i, y_i) of i-th dart is `(x[i],y[i])`



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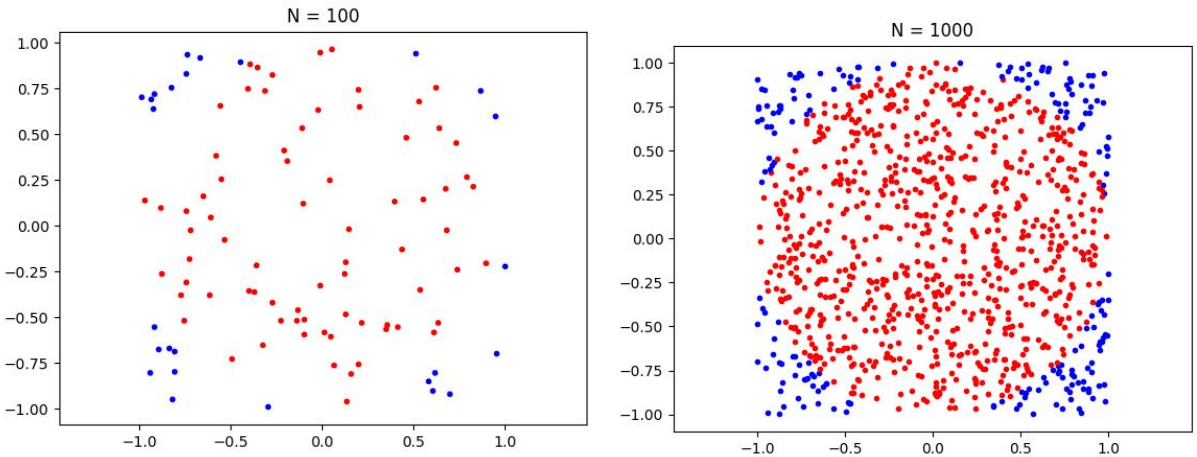

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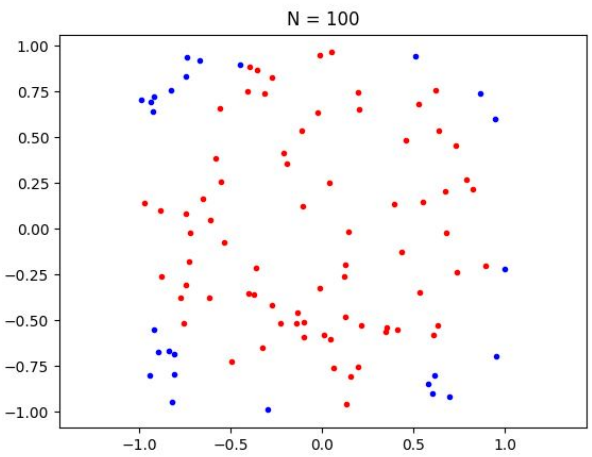

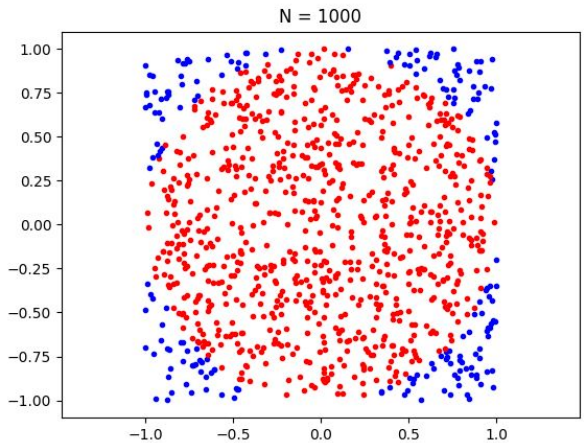

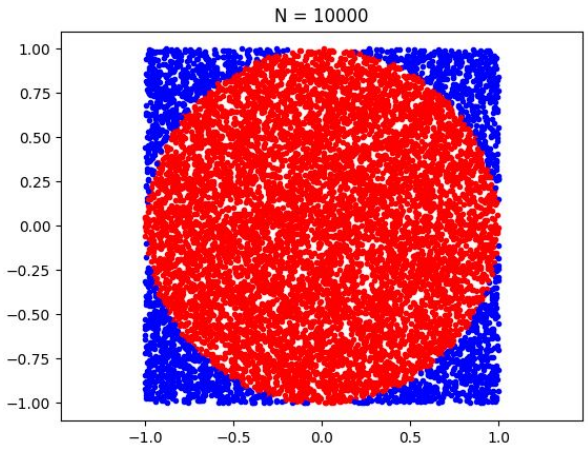

Random floats: estimate π

Example 4

- modify Example 3 to count number of points inside (or on) circle
- use your results to estimate the value of π

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- use your results to estimate the value of π
- strategy:
  - area of square: $2 \times 2 = 4$
  - area of circle: πr^2, where radius $r = 1$, hence area is π

$$R = \frac{\text{area of circle}}{\text{area of square}} = \frac{\pi}{4}$$

Random floats: estimate π

Example 4

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- use your results to estimate the value of π
- strategy:
  - area of square: $2 \times 2 = 4$
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$$R = \frac{\text{area of circle}}{\text{area of square}} = \frac{\pi}{4}$$

$$\begin{aligned} \text{estimate of } \pi &= 4 \times \text{estimate of ratio } R \\ &= 4 \times \frac{\text{number of points in circle}}{\text{total number of points}} \end{aligned}$$

Estimate π: code

```
1  import numpy as np
2  import matplotlib.pyplot as plt
3
4  # generate random array of (x,y) pairs covering
5  # square with edge length 2
6  N = 10000
7  x = np.random.uniform(-1, 1, N)       # N floats from [-1,1)
8  y = np.random.uniform(-1, 1, N)       # N floats from [-1,1)
9
10 insideCnt = 0
11 for i in range(0,N,1):
12     if x[i]**2 + y[i]**2 <= 1:
13         plt.plot(x[i],y[i],'r.')
14         insideCnt += 1
15     else:
16         plt.plot(x[i],y[i],'b.')
17
18 R = insideCnt/N
19 print('Estimate of pi: {}'.format(4*R))
20
21 plt.axis('equal')
22 plt.show()
```

- Live demo of `estimatePi.py`

2) Reading from spreadsheets

- so far have been working "toy problems" with small data sets
- engineers and scientists often work with *large* datasets
  - spreadsheets eg: CSV or XML files
  - databases eg: SQL files
  - wide range of other software packages
- there's a package for that: it's called `pandas`

  ...and we can import it just like `numpy` and `matplotlib`

```
1 import pandas as pd
```

Data import using pandas

- to import data from *comma-separated values* (CSV) file into Python:

```
1 import pandas as pd
2 mydata = pd.read_csv('filename.csv')
```

- if CSV file is not in the same folder as Python project, need to specify its location with a path:

```
1 import pandas as pd
2 mydata = pd.read_csv('c:\Myfolder\filename.csv')
```

Checking data import

- `pandas` imports contents of spreadsheet into something called a *data structure*
  - we won't spend any time on today but may get back to later in the course

- To check data imported into `mydata` the following instruction is very useful:

```
1 print(mydata.head())
```

- This prints out the first few lines of the data set

Extracting data into an array

- One final very useful instruction will extract a column of the data and save it as a `numpy` array
  - uses the column name in the original spreadsheet

```
1 mycolumn = mydata['column_name'].values
```

- We can now process this data using the Python skills we have been building in this course

Example

- We have a CSV spreadsheet (`Rainfall.csv`) which records annual rainfall for 20 regions over the last 10 years

	A	B	C	D	E	F	G
1	Region	Rainfall 2010	Rainfall 2012	Rainfall 2014	Rainfall 2016	Rainfall 2018	Rainfall 2020
2	A	67	78	70	78	63	65
3	B	74	79	79	79	64	74
4	C	75	80	80	80	68	60
5	D	76	81	81	81	69	61
6	E	77	67	67	67	67	62
7	F	78	68	68	68	90	63
8	G	79	79	79	79	64	64
9	H	80	80	80	80	68	68
10	I	81	67	67	67	65	69
11	J	67	74	74	78	74	67
12	K	68	75	75	79	60	90
13	L	60	76	76	80	61	60
14	M	68	77	75	81	62	68
15	N	69	69	69	67	60	60
16	O	70	70	63	68	34	34
17	P	65	65	77	79	65	65
18	Q	66	66	69	80	57	57
19	R	67	67	70	67	67	67
20	S	90	90	65	90	56	56
21	T	85	85	90	85	80	80
22							

- We would like to know how many regions have seen a reduction in rainfall between 2010 and 2020

Example

```
1 import pandas as pd
2
3 # import the rainfall data
4 Rainfalldata = pd.read_csv("Rainfall.csv")
5 print(Rainfalldata.head())
6
7 # extract the columns for 2010 and 2020
8 Rainfall2010 = Rainfalldata['Rainfall 2010'].values
9 Rainfall2020 = Rainfalldata['Rainfall 2020'].values
```

Example

```
# How many regions have seen a decrease in rainfall
N = len(Rainfall2010)
count = 0
for i in range(0, N, 1):
    if Rainfall2020[i] < Rainfall2010[i]:
        count = count + 1

percentage_decreased = count/N*100

print('Of the {} regions, {} have reduced rainfall
    which is {:f6.2}% '.format(N, count,
    percentage_decreased))
```

Lecture summary

1. Using random numbers
2. Reading from spreadsheets

- **Next lecture:** functions in Python, Chapter 4 of LL textbook