Using Statistical Distributions to Generate Random Test Data

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Overview

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What is Software Testing?

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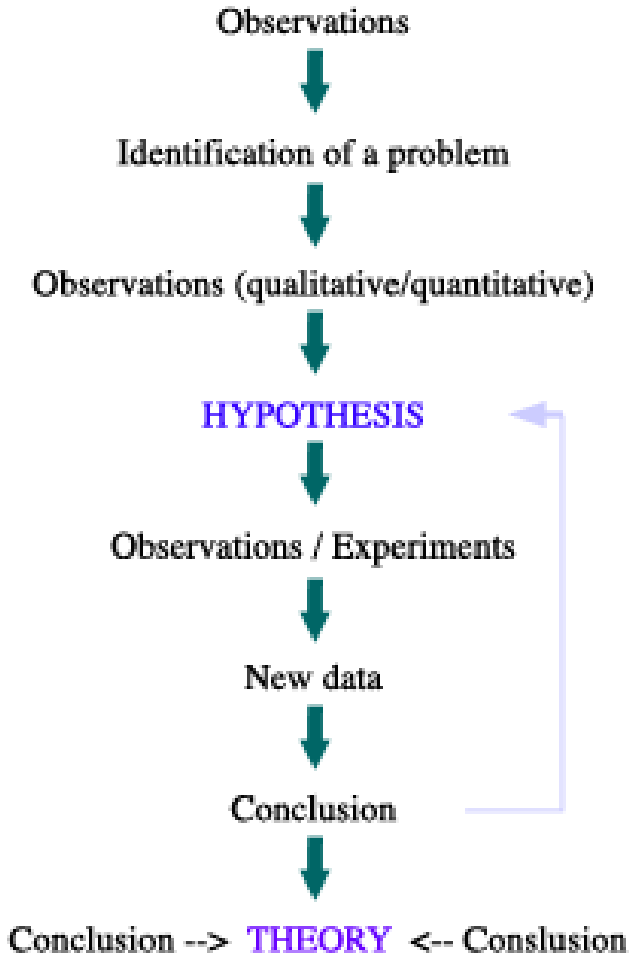

Why is it so hard?

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```
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files/xoklpenyj/xvrr/xmnyjnm/vvfpm.c
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files/xoklpenyj/xvrr/xn/dcwhu.h
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files/xqftrpq/cru/ljxav.o
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files/xqftrpq/cru/rklnx.h
files/xqftrpq/cru/rklnx.o
files/xqftrpq/cru/sen.exe
files/xqftrpq/cru/wtmyn.c
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files/xqftrpq/gcq.tgz
files/xqftrpq/vs/lpfqt.h
files/xqftrpq/vs/qywyn.c
files/xqftrpq/vs/qywyn.h
```

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cis415-2 [Running]

Applications | Terminal - cis415@cis41... | 15:37 | cis415

Terminal - cis415@cis415-arch:~/uoregon-cis415/project2

File Edit View Terminal Tabs Help

```
Info: application 7 has queued write to sector 3592 (blocking)
Info: application 8 has acquired a sector descriptor.
Info: application 8 is queueing write to sector 3987
Info: application 8 has queued write to sector 3987 (blocking)
Info: application 1 has acquired a sector descriptor.
Info: application 1 is queueing write to sector 1175
Info: application 1 has queued write to sector 1175 (nonblocking)
[Device> sector 4004 successfully written by process 2
Info: application 9 has acquired a sector descriptor.
Info: application 9 is queueing read of sector 3854
Info: application 9 has queued read of sector 3854 (blocking)
Info: application 5 has acquired a sector descriptor.
Info: application 5 is queueing write to sector 1111
Info: application 5 has queued write to sector 1111 (nonblocking)
Info: application 3 has acquired a sector descriptor.
Info: application 3 is queueing read of sector 1537
Info: application 3 has queued read of sector 1537 (nonblocking)
Info: application 9 has acquired a sector descriptor.
Info: application 9 is queueing write to sector 3402
Info: application 9 has queued write to sector 3402 (blocking)
Info: application 8 has acquired a sector descriptor.
Info: application 8 is queueing read of sector 3175
Info: application 8 has queued read of sector 3175 (blocking)
Info: application 3 (writer) write to sector 2192 was successful
[Device> sector 1091 successfully written by process 10
Info: application 5 (reader) read from sector 1477 was successful
Info: application 5 (reader) has released a sector descriptor.
Info: application 6 has acquired a sector descriptor.
Info: application 6 is queueing read of sector 821
Info: application 6 has queued read of sector 821 (nonblocking)
Info: application 2 (writer) write to sector 4004 was successful
[Device> sector 3592 successfully written by process 7
Info: application 10 (reader) read from sector 1331 was successful
Info: application 10 (reader) has released a sector descriptor.
Info: application 2 has acquired a sector descriptor.
Info: application 2 is queueing read of sector 117
Info: application 2 has queued read of sector 117 (nonblocking)
[Device> sector 3854 successfully read by process 9
[Device> sector 1537 successfully read by process 3
[Device> sector 3987 successfully written by process 8
Info: application 7 (writer) write to sector 3592 was successful
```

Left ⌘

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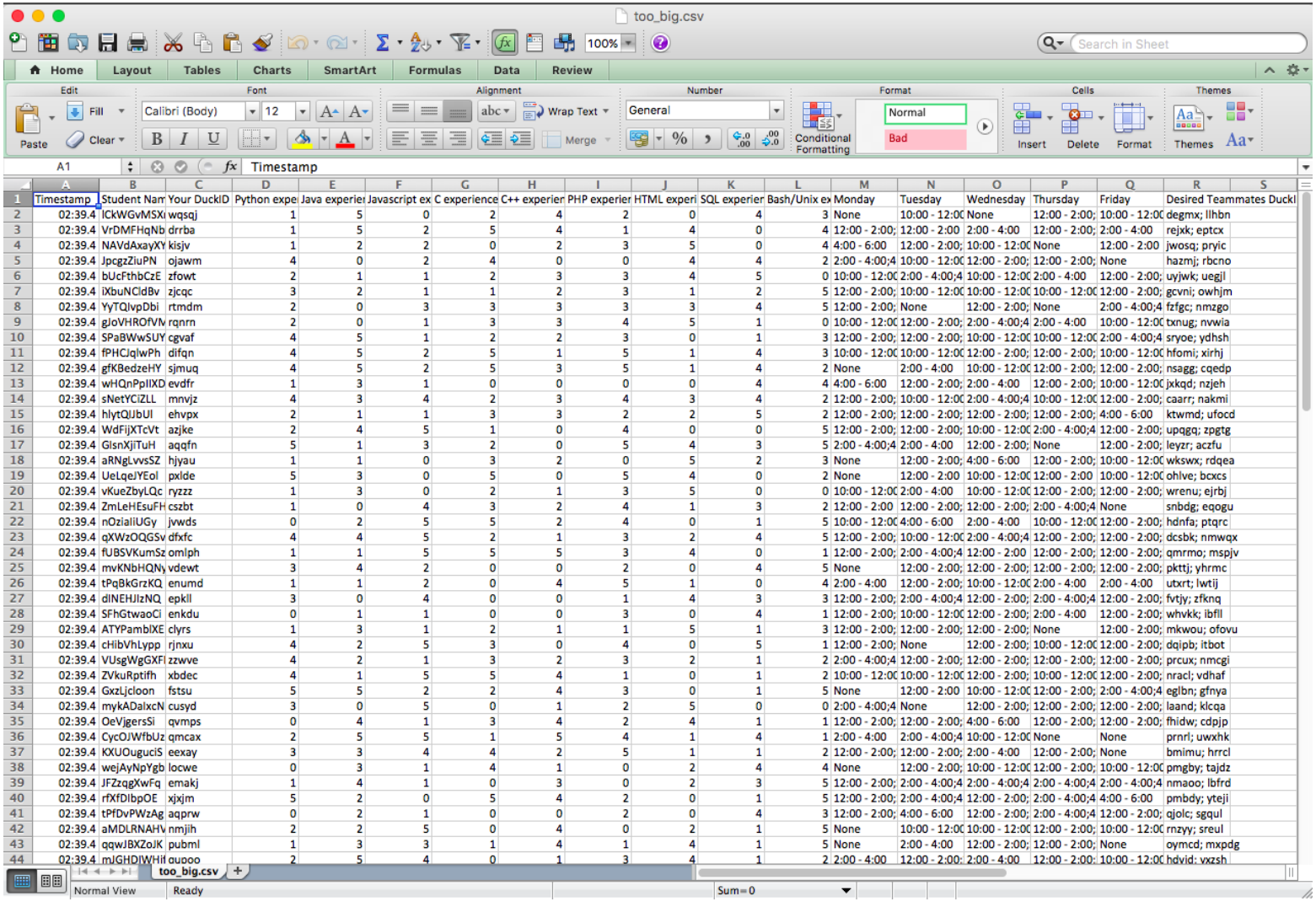

Timestamp	Student Nam	Your DuckID	Python expe	Java experier	Javascript ex	C experience	C++ experier	PHP experier	HTML experi	SQL experier	Bash/Unix ex	Monday	Tuesday	Wednesday	Thursday	Friday	Desired Teammates Duckl
02:39.4	lCkWGvMSXi	wqsqj	1	5	0	2	4	2	0	4	3	None	10:00 - 12:0	None	12:00 - 2:00;	10:00 - 12:0	degmx; llhbn
02:39.4	VrDMFHqNb	drrba	1	5	2	5	4	1	4	0	4	12:00 - 2:00;	12:00 - 2:00	2:00 - 4:00	12:00 - 2:00;	2:00 - 4:00	rejxk; eptcx
02:39.4	NAVdAxayXY	kisjv	1	2	2	0	2	3	5	0	4	4:00 - 6:00	12:00 - 2:00;	10:00 - 12:0	None	12:00 - 2:00	jwosq; pryic
02:39.4	JpcgzZiuPN	ojawm	4	0	2	4	0	0	4	4	2	2:00 - 4:00;4	10:00 - 12:0	12:00 - 2:00;	12:00 - 2:00;	None	hazmj; rbcno
02:39.4	bUcFthbCzE	zfowt	2	1	1	2	3	3	4	5	0	10:00 - 12:0	2:00 - 4:00;4	10:00 - 12:0	2:00 - 4:00	12:00 - 2:00;	uyjwk; uegjl
02:39.4	iXbuNCldBv	zjcqc	3	2	1	1	2	3	1	2	5	12:00 - 2:00;	10:00 - 12:0	10:00 - 12:0	10:00 - 12:0	12:00 - 2:00;	gcvni; owhjm
02:39.4	YyTQlvpDbi	rtmdm	2	0	3	3	3	3	3	4	5	12:00 - 2:00;	None	12:00 - 2:00;	None	2:00 - 4:00;4	fzfgc; nmzgo
02:39.4	gJoVHROfVM	rqnrn	2	0	1	3	3	4	5	1	0	10:00 - 12:0	12:00 - 2:00;	2:00 - 4:00;4	2:00 - 4:00	10:00 - 12:0	txnug; nvwia
02:39.4	SPaBWwSUY	cgvaf	4	5	1	2	2	3	0	1	3	12:00 - 2:00;	12:00 - 2:00;	10:00 - 12:0	10:00 - 12:0	2:00 - 4:00;4	sryoe; ydhsh
02:39.4	fPHCJqlwPh	difqn	4	5	2	5	1	5	1	4	3	10:00 - 12:0	10:00 - 12:0	12:00 - 2:00;	12:00 - 2:00;	10:00 - 12:0	hfomi; xirhj
02:39.4	gfKBedzeHY	sjmuq	4	5	2	5	3	5	1	4	2	None	2:00 - 4:00	10:00 - 12:0	12:00 - 2:00;	12:00 - 2:00;	nsagg; cqedp
02:39.4	wHQnPpIIXD	evdfr	1	3	1	0	0	0	0	4	4	4:00 - 6:00	12:00 - 2:00;	2:00 - 4:00	12:00 - 2:00;	10:00 - 12:0	jxkqd; nzjeh
02:39.4	sNetYCiZLL	mnvjz	4	3	4	2	3	4	3	4	2	12:00 - 2:00;	10:00 - 12:0	2:00 - 4:00;4	10:00 - 12:0	12:00 - 2:00;	caarr; nakmi
02:39.4	hlytQlJbUl	ehvpx	2	1	1	3	3	2	2	5	2	12:00 - 2:00;	12:00 - 2:00;	12:00 - 2:00;	12:00 - 2:00;	4:00 - 6:00	ktwmd; ufocd
02:39.4	WdFijXTcVt	azjke	2	4	5	1	0	4	0	0	5	12:00 - 2:00;	12:00 - 2:00;	10:00 - 12:0	2:00 - 4:00;4	12:00 - 2:00;	upqgq; zpgtg
02:39.4	GlsnXjiTuH	aqqfn	5	1	3	2	0	5	4	3	5	2:00 - 4:00;4	2:00 - 4:00	12:00 - 2:00;	None	12:00 - 2:00;	leyzr; aczfu
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02:39.4	UeLqeJYEol	pxlde	5	3	0	5	0	5	4	0	2	None	12:00 - 2:00	10:00 - 12:0	12:00 - 2:00	10:00 - 12:0	ohlve; bcxcs
02:39.4	vKueZbyLQc	ryzzz	1	3	0	2	1	3	5	0	0	10:00 - 12:0	2:00 - 4:00	10:00 - 12:0	12:00 - 2:00;	12:00 - 2:00;	wrenu; ejrbj
02:39.4	ZmLeHEsuFH	cszbt	1	0	4	3	2	4	1	3	2	12:00 - 2:00	12:00 - 2:00;	12:00 - 2:00;	2:00 - 4:00;4	None	snbdg; eqogu
02:39.4	nOzialiUGy	jvwds	0	2	5	5	2	4	0	1	5	10:00 - 12:0	4:00 - 6:00	2:00 - 4:00	10:00 - 12:0	12:00 - 2:00;	hdnfa; ptqrc
02:39.4	qXWzOQGSv	dfxfc	4	4	5	2	1	3	2	4	5	12:00 - 2:00;	10:00 - 12:0	2:00 - 4:00;4	12:00 - 2:00;	12:00 - 2:00;	dcsbk; nmwqx
02:39.4	fUBSVKumSz	omlph	1	1	5	5	5	3	4	0	1	12:00 - 2:00;	2:00 - 4:00;4	12:00 - 2:00	12:00 - 2:00;	12:00 - 2:00;	qmrmo; mspjv
02:39.4	mvKNbHQNy	vdewt	3	4	2	0	0	2	0	4	5	None	12:00 - 2:00;	12:00 - 2:00;	12:00 - 2:00;	12:00 - 2:00;	pkttj; yhrmc
02:39.4	tPqBkGrzKQ	enumd	1	1	2	0	4	5	1	0	4	2:00 - 4:00	12:00 - 2:00;	10:00 - 12:0	2:00 - 4:00	2:00 - 4:00	utxrt; lwtij
02:39.4	dlNEHJIzNQ	epkll	3	0	4	0	0	1	4	3	3	12:00 - 2:00;	2:00 - 4:00;4	12:00 - 2:00;	2:00 - 4:00;4	12:00 - 2:00;	fvtjy; zfknq
02:39.4	SFhGtwaoCi	enkdu	0	1	1	0	0	3	0	4	1	12:00 - 2:00;	10:00 - 12:0	12:00 - 2:00;	2:00 - 4:00	12:00 - 2:00;	whvkk; ibfll
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02:39.4	cHibVhLypp	rjnxu	4	2	5	3	0	4	0	5	1	12:00 - 2:00;	None	12:00 - 2:00;	10:00 - 12:0	12:00 - 2:00;	dqipb; itbot
02:39.4	VUsgWgGXFl	zzwve	4	2	1	3	2	3	2	1	2	2:00 - 4:00;4	12:00 - 2:00;	12:00 - 2:00;	12:00 - 2:00;	12:00 - 2:00;	prcux; nmcgi
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02:39.4	mykADaIxcN	cusyd	3	0	5	0	1	2	5	0	0	2:00 - 4:00;4	None	12:00 - 2:00;	12:00 - 2:00;	12:00 - 2:00;	laand; klcqa
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02:39.4	KXUOuguciS	eexay	3	3	4	4	2	5	1	1	2	12:00 - 2:00;	12:00 - 2:00;	2:00 - 4:00	12:00 - 2:00;	None	bmimu; hrrcl
02:39.4	wejAyNpYgb	locwe	0	3	1	4	1	0	2	4	4	None	12:00 - 2:00;	10:00 - 12:0	12:00 - 2:00;	10:00 - 12:0	pmgby; tajdz
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02:39.4	rfXfDlbpOE	xjxjm	5	2	0	5	4	2	0	1	5	12:00 - 2:00;	2:00 - 4:00;4	12:00 - 2:00;	2:00 - 4:00;4	4:00 - 6:00	pmbdy; yteji
02:39.4	tPfDvPWzAg	aqprw	0	2	1	0	0	2	0	4	3	12:00 - 2:00;	4:00 - 6:00	12:00 - 2:00;	2:00 - 4:00;4	12:00 - 2:00;	qjolc; sgqul
02:39.4	aMDLRNAHv	nmjih	2	2	5	0	4	0	2	1	5	None	10:00 - 12:0	10:00 - 12:0	12:00 - 2:00;	10:00 - 12:0	rnzyy; sreul
02:39.4	qqwJBXZoJK	pubml	1	3	3	1	4	1	4	1	5	None	2:00 - 4:00	12:00 - 2:00;	12:00 - 2:00;	None	oymcd; mxpdg
02:39.4	mJGHDlWHif	qupoo	2	5	4	0	1	3	4	1	2	2:00 - 4:00	12:00 - 2:00;	2:00 - 4:00	12:00 - 2:00;	10:00 - 12:0	hdvid; vxzsh

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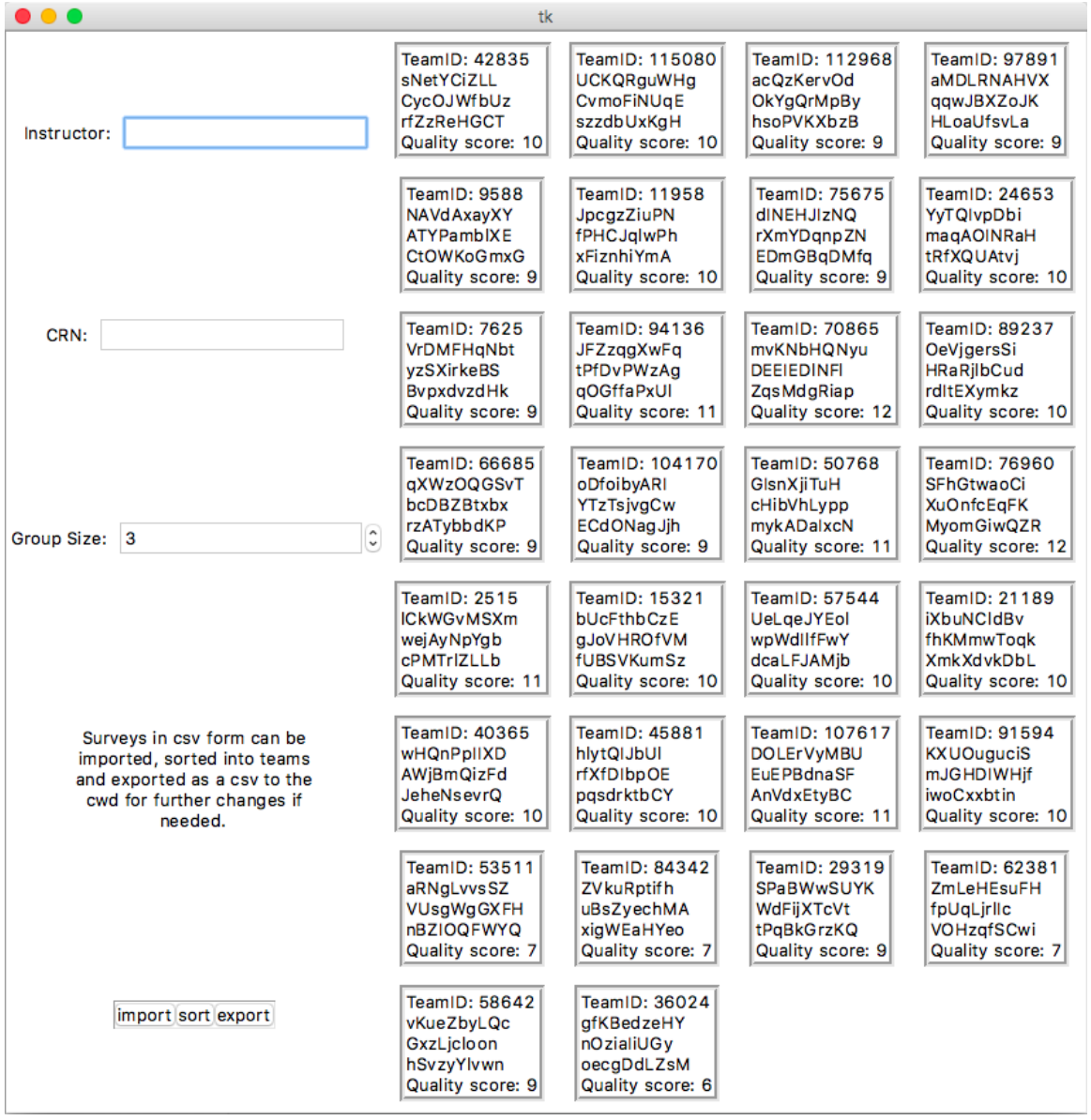

Well if it's so hard why bother?

5

An Investigation of the Therac-25 Accidents

Nancy G. Leveson, University of Washington
Clark S. Turner, University of California, Irvine

Computers are increasingly being introduced into safety-critical systems and, as a consequence, have been involved in accidents. Some of the most widely cited software-related accidents in safety-critical systems involved a computerized radiation therapy machine called the Therac-25. Between June 1985 and January 1987, six known accidents involved massive overdoses by the Therac-25 — with resultant deaths and serious injuries. They have been described as the worst series of radiation accidents in the 35-year history of medical accelerators.[1]

Overview

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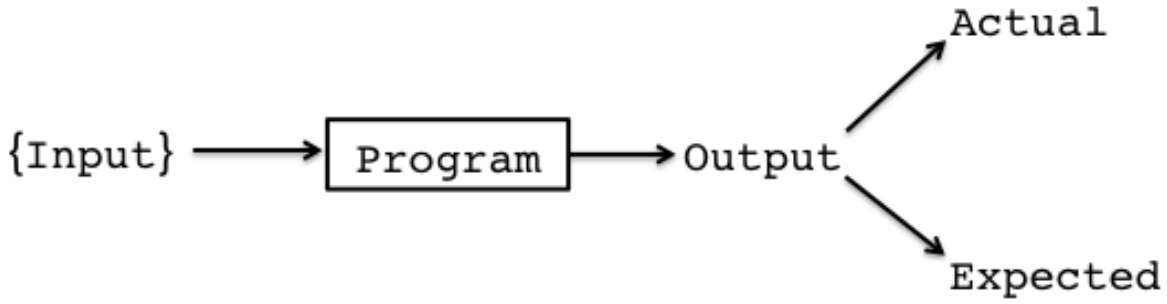
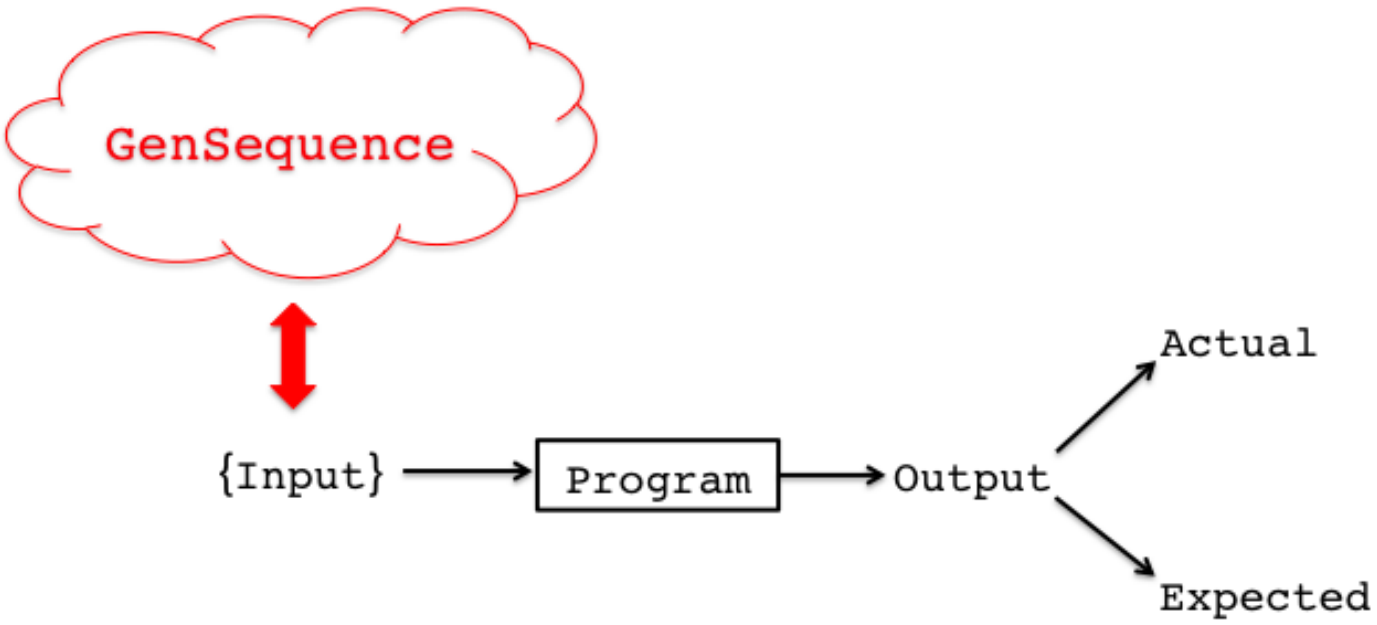
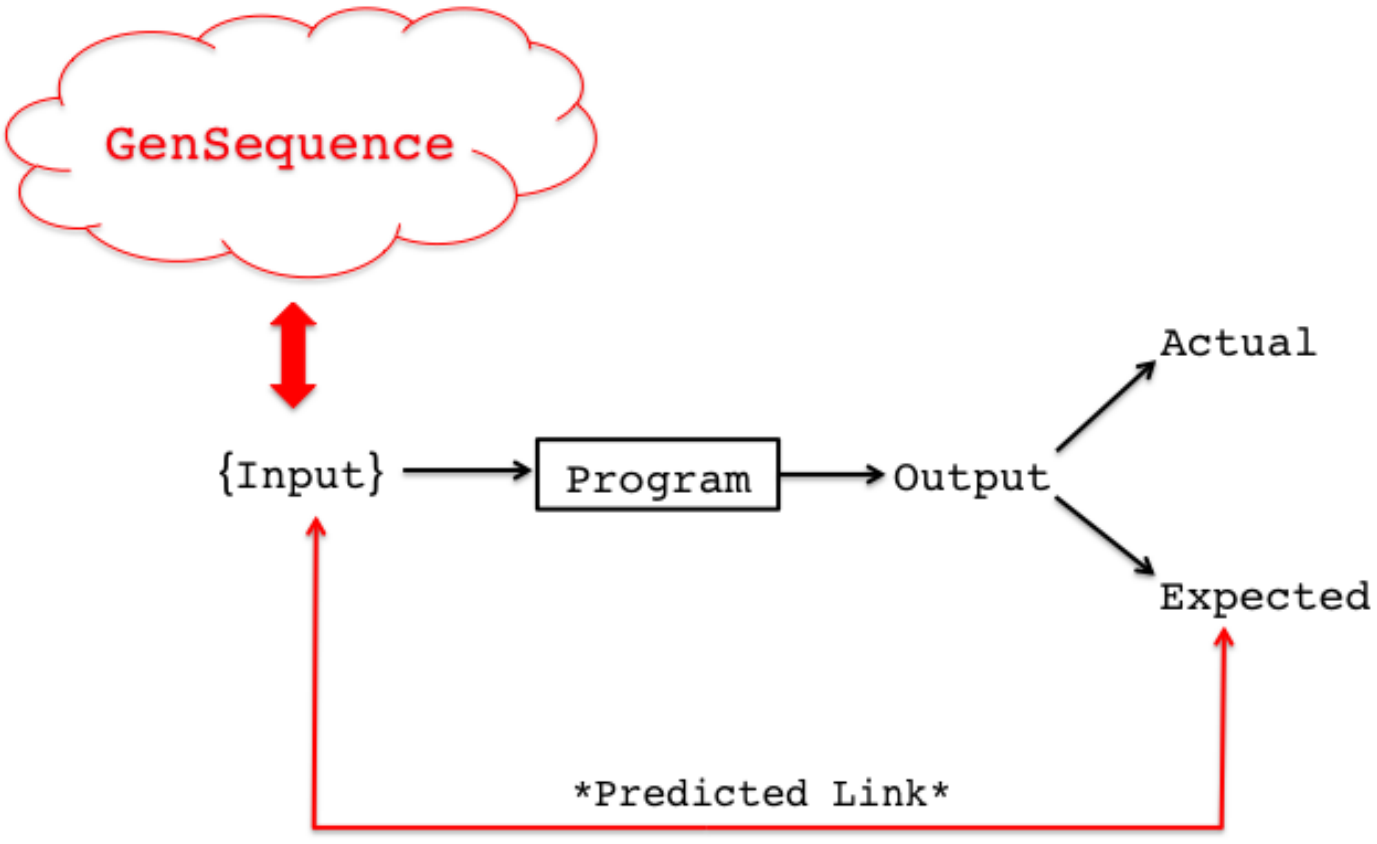



GenSequence
{Input}
Program
Output
Actual
Expected

Goals

- Ease of use
- End-to-end automation
- Insight into what the input looks like

GenSequence



Overview

Pairwise Testing

NEC
Empowered by Innovation

Pairwise Testing

University of Waterloo

- The total number of all-combination test cases is $2 \times 2 \times 2 = 8$
- However, a subset of four test cases, as shown in Table 9.5, covers all pairwise combinations

Test Case Id	Input X	Input Y	Input Z
TC_1	$True$	0	Q
TC_2	$True$	5	R
TC_3	$False$	0	Q
TC_4	$False$	5	R

Table 9.5: Pairwise test cases for system S.

ParmGen

Item Purchased	*Price*	*Delivery Method*
Large Item	Expensive	Lightspeed
Small Item	Mid-price	SnailMail
ExtraSmall Item	Cheap	Ultrafast

Tabel: Possibilities

Item Purchased	*Price*	*Delivery Method*
Boat	$10,000.00	Space Rocket

Tabel: Concrete Test Vector

ParmGen Space

Cats	*Dogs*
10	1

Tabel: Unit Parameter

Cats	*Dogs*
10	1
1	1
10	10
10	100
10	1
1	10
10	10
10	1
1	1
10	100
100	1
1	10

Tabel: System Parameter

ParmGen Space

Cats is *not* just 100.

Cats is [10, 1, 10, 10, 10, 1, 10, 10, 1, 10, 100, 1, ...]

Cats is [1, 2, 2, 3, 3, 3, 4, 3, 2, 1, 1]

ParmGen Space

Cats is *not* just 100.

Cats is [10, 1, 10, 10, 10, 1, 10, 10, 1, 10, 100, 1, ...]

Cats is [1, 2, 2, 3, 3, 3, 4, 3, 2, 1, 1]

100 points – average = 15, std. deviation = 5

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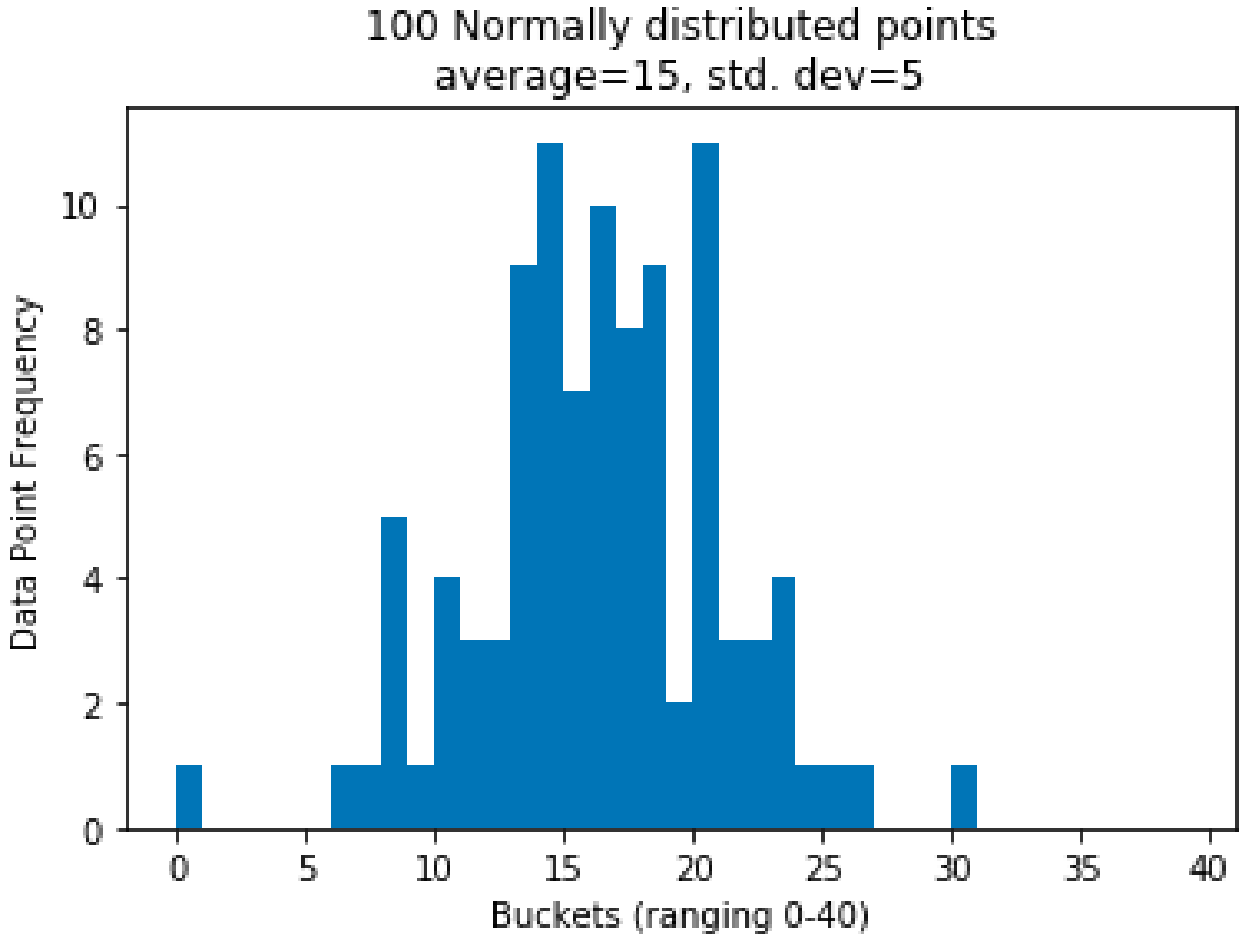

Law of Large Numbers

- Bernoulli's Principle
- Selection Scheme

10,000 points – average = 15, std. deviation = 5

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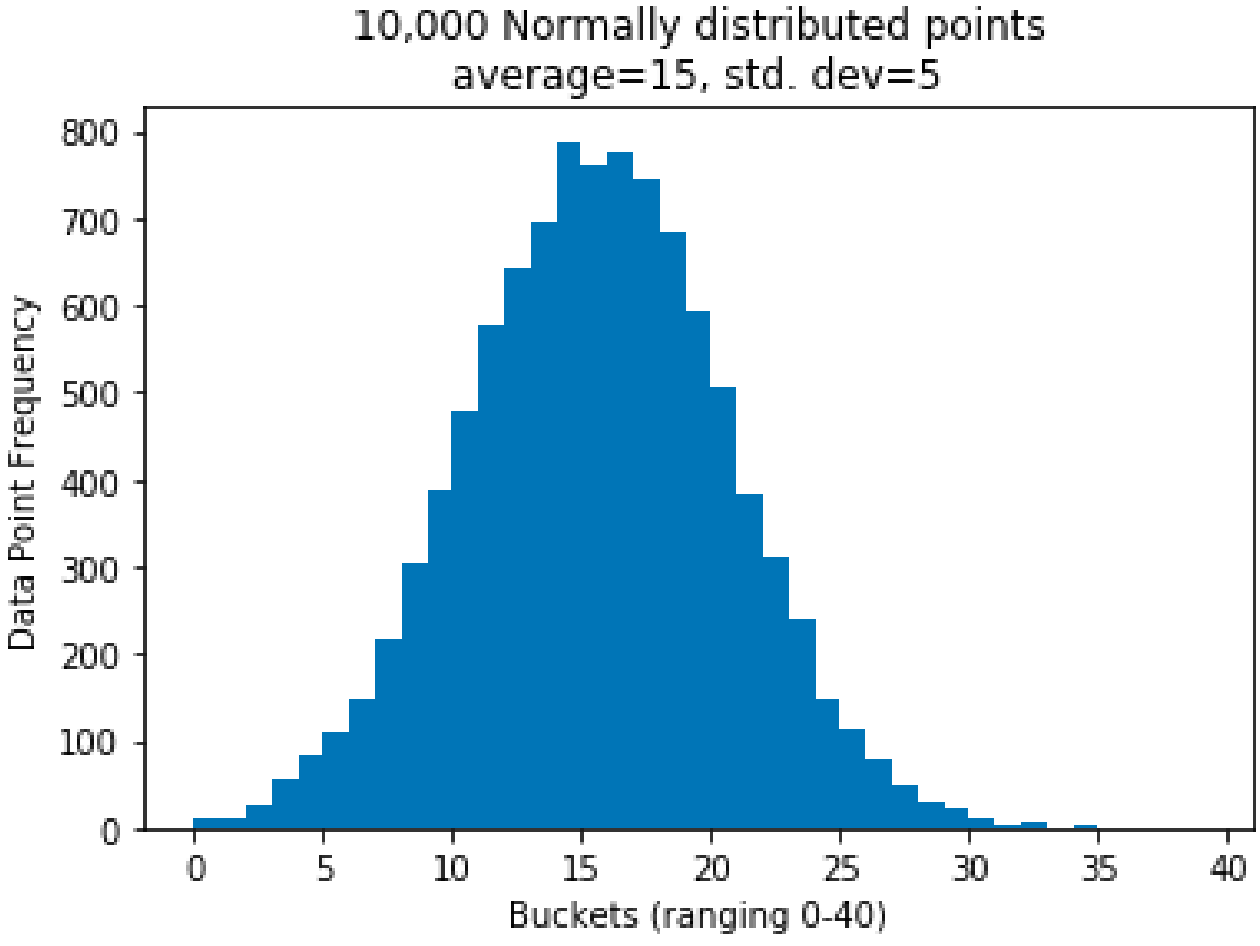

300 points – average = 15, std. deviation = 5

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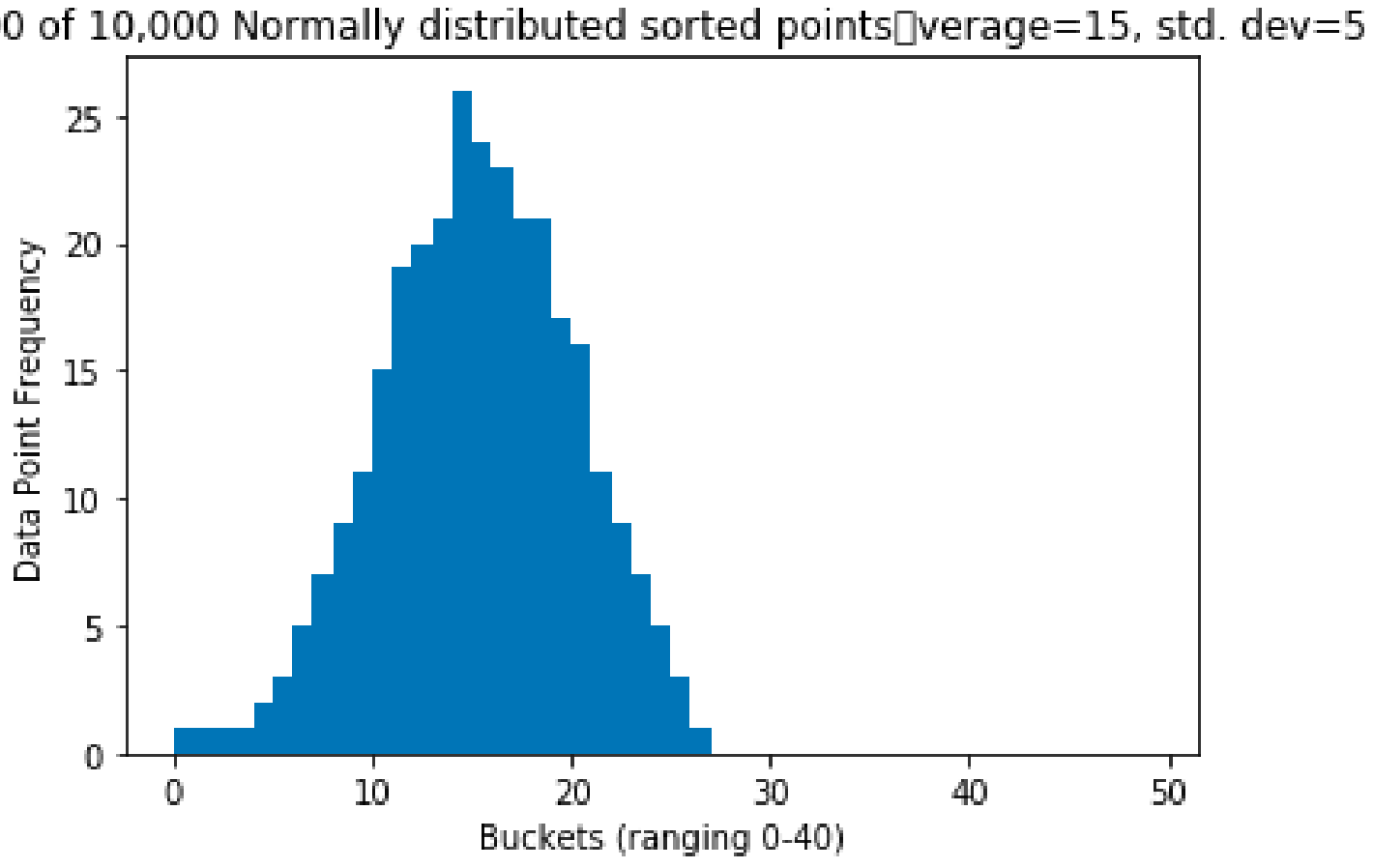

A Variety of Statistical Distributions

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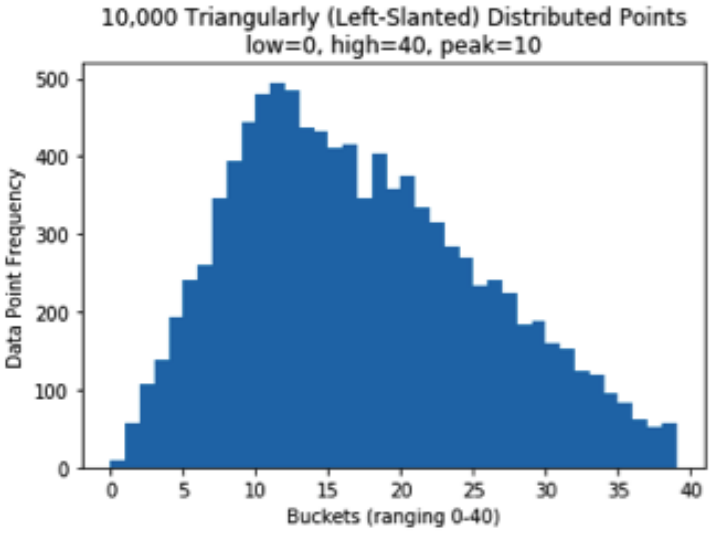
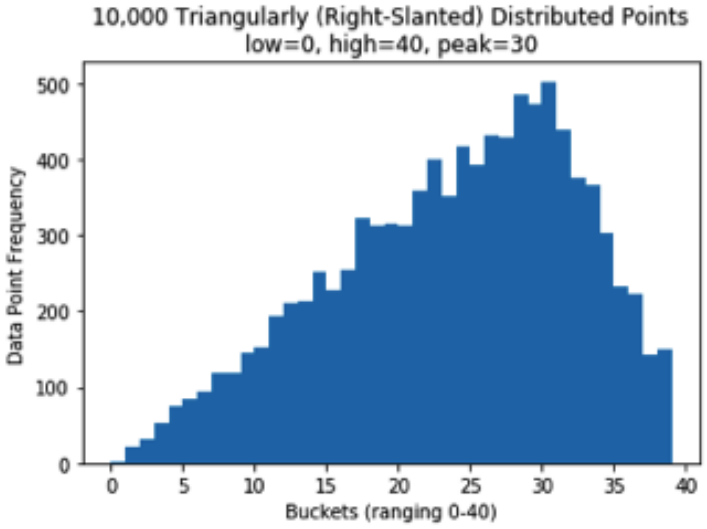
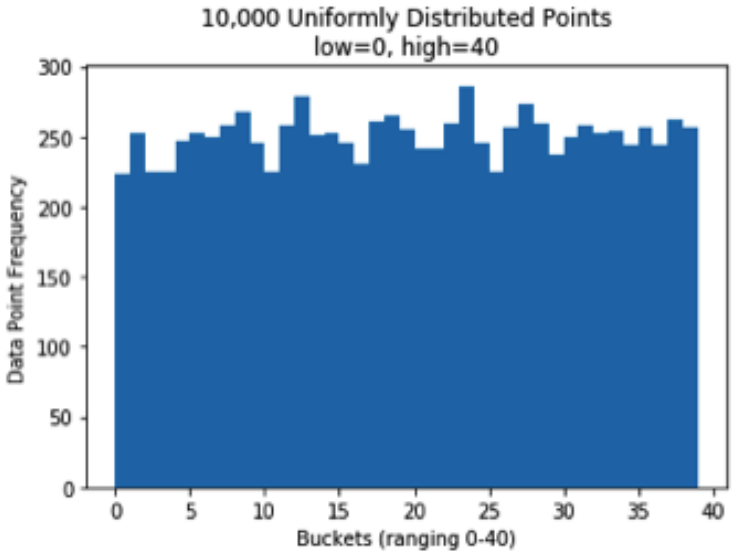
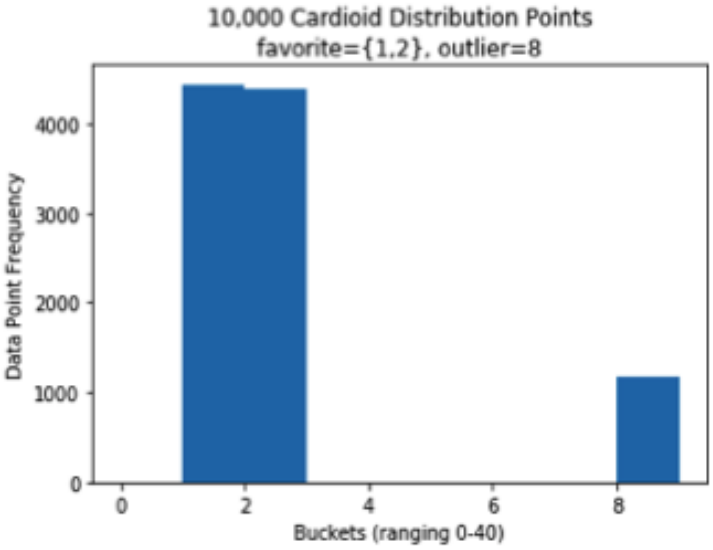




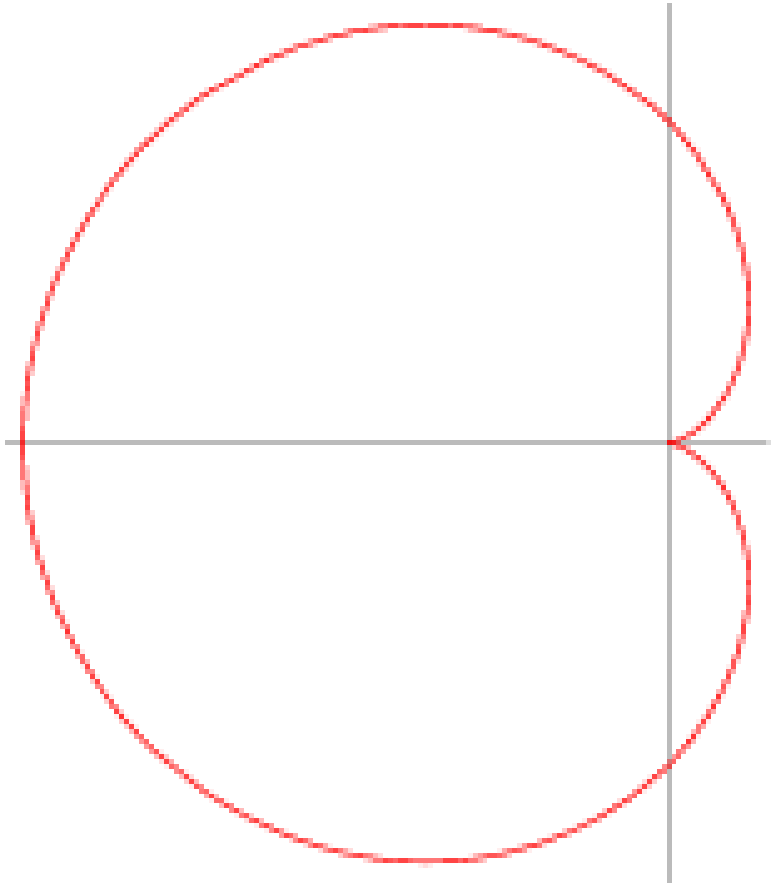




Cardioids

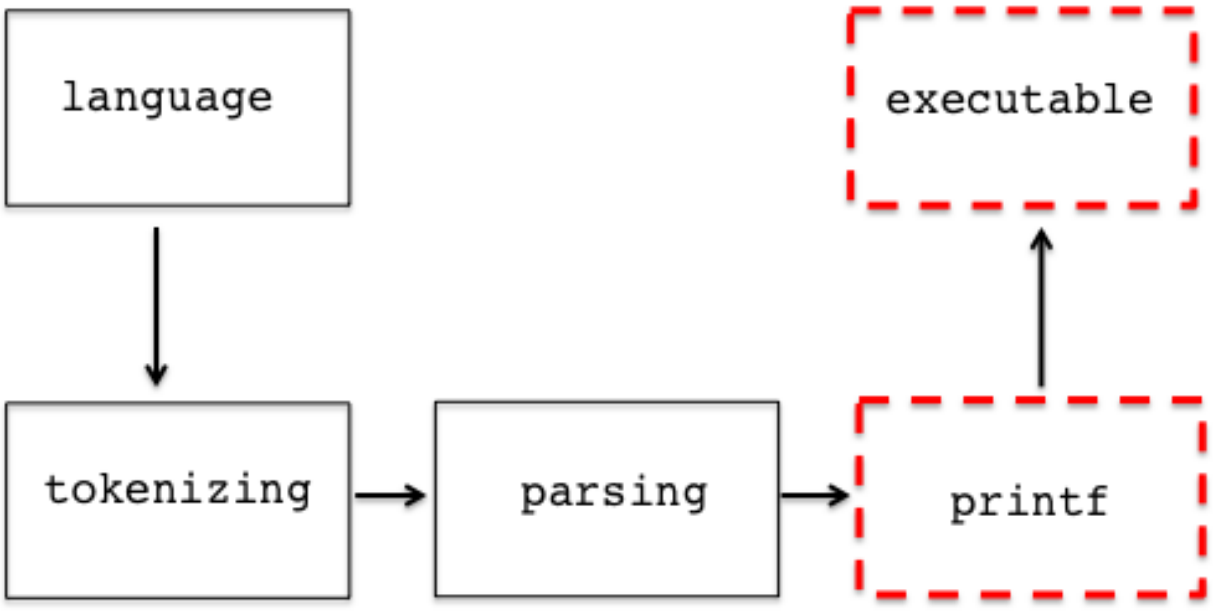
Jamie L. Zimmerman

$$r = \alpha \pm \alpha cos\theta$$



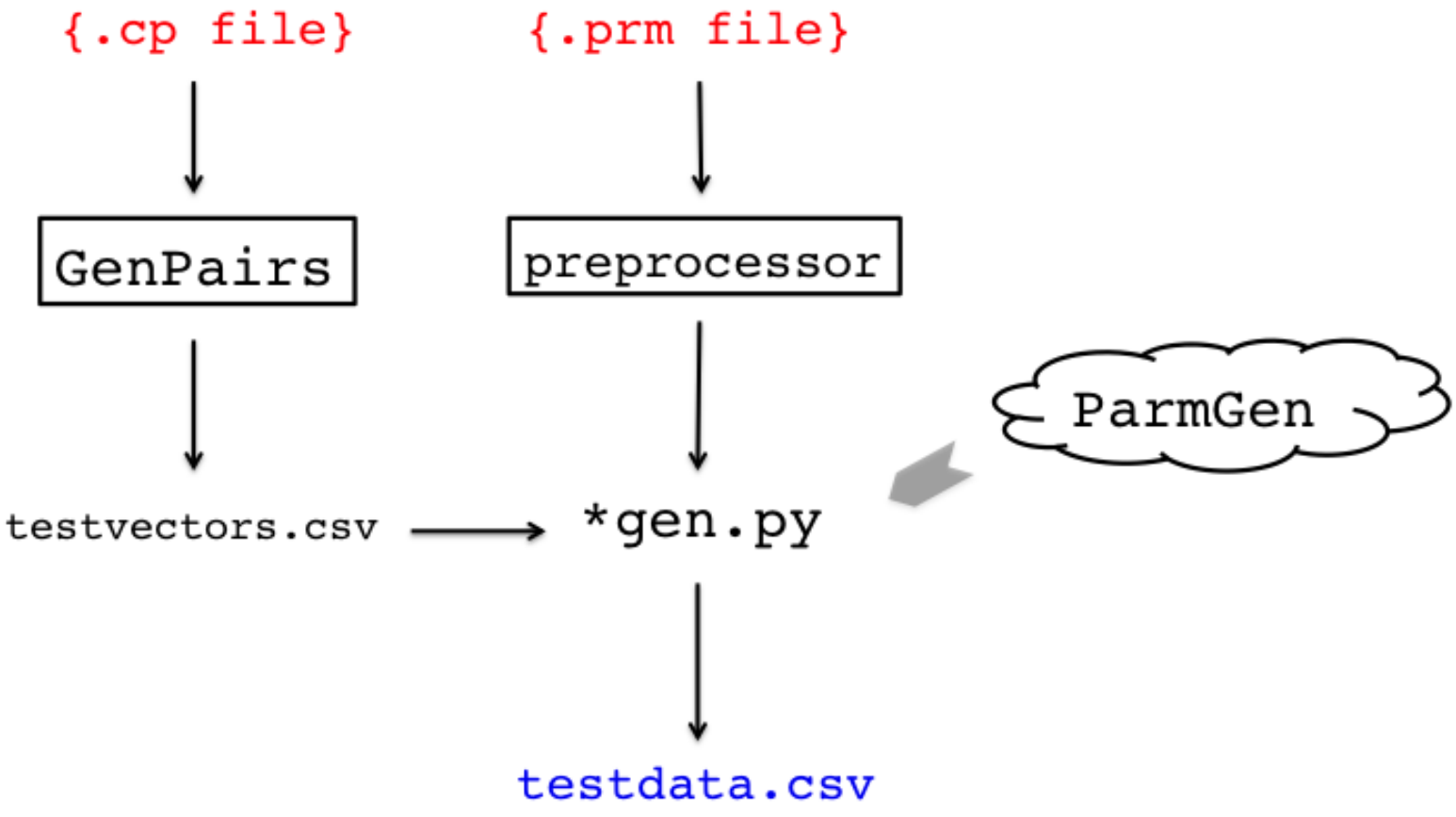
Preprocessor

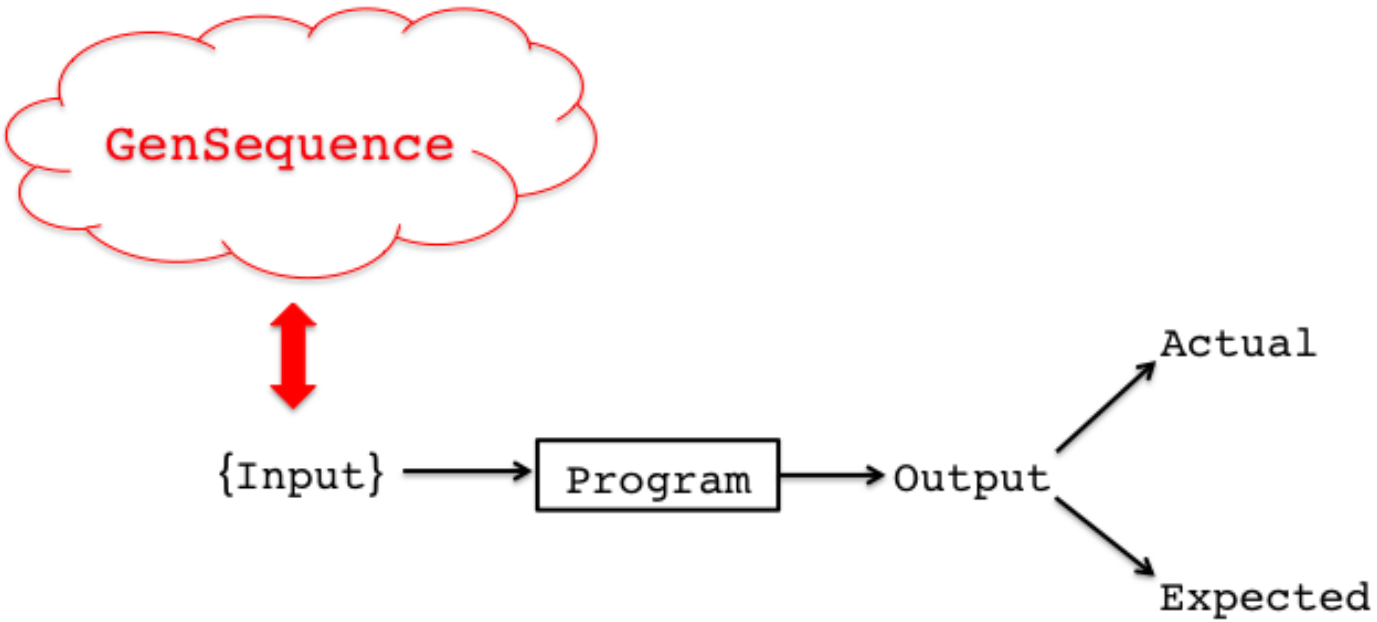
Jamie L. Zimmerman



GenSequence

Jamie L. Zimmerman




GenSequence
{Input}
Program
Output
Actual
Expected

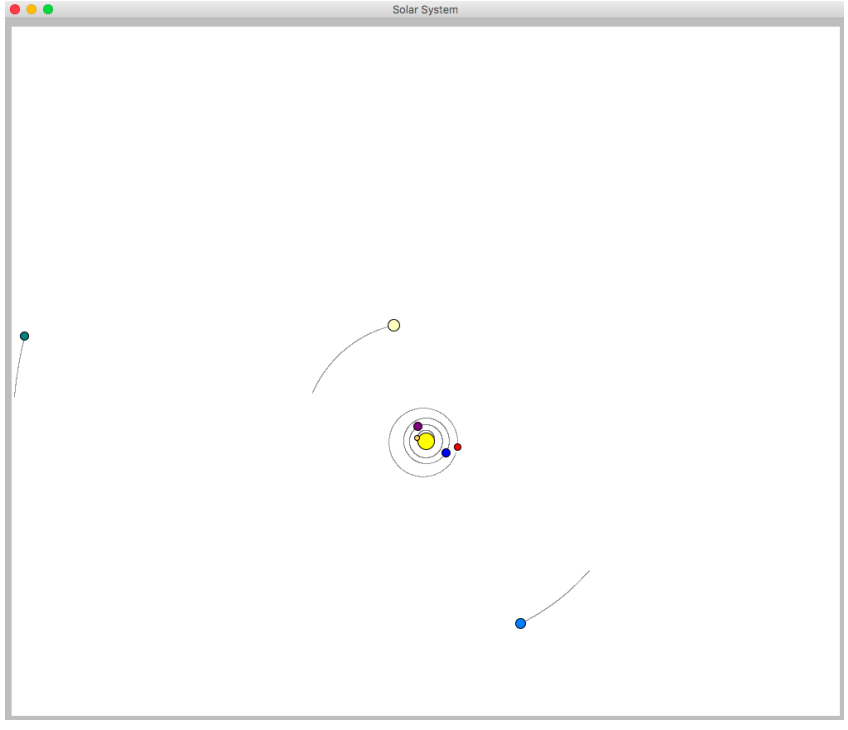
Overview

Status Quo

Jamie L. Zimmerman

1 file to test with: “solarsystem.csv”

```
sun, 1.9891E+30, 0, 0, 0, 0, 0, 0, 10, #ffff00
mercury, 3.302E+23, 3.83713E+10, 2.877025E+10, -1.175808E+09, -38787.67, 41093.05, 6918.461, 3, #ffcc66
venus, 4.8685E+24, -5.377313E+09, -1.085956E+11, -1.164748E+09, 34741.48, -1865.747, -2031.506, 5, #800080
earth, 5.9736E+24, -2.700743E+10, 1.446007E+11, 9686451, -29770.44, -5568.042, 0.3961261, 5, #0000ff
mars, 6.4185E+23, 1.983825E+11, 7.422924E+10, -3.334841E+09, -7557.626, 24761.27, 704.7457, 4, #ff0000
jupiter, 1.89813E+27, -7.496502E+11, -3.201711E+11, 1.811155E+10, 4982.522, -11417.83, -64.66531, 7, #ffffbf
saturn, 5.68319E+26, 1.082806E+12, 8.510841E+11, -5.793461E+10, -6487.118, 7565.952, 125.4422, 6, #0080ff
uranus, 8.68103E+25, -2.724616E+12, -2.894003E+11, 3.428801E+10, 671.3469, -7099.093, -35.04028, 5, #008080
neptune, 1.0241E+26, -2.328072E+12, -3.891086E+12, 1.337436E+11, 4633.961, -2767.423, -49.57268, 5, #004080
pluto, 1.314E+22, -4.551135E+12, 3.175277E+11, 1.282177E+12, 635.998, -5762.115, 440.8821, 2, #dddddd
```



Multiple Test Cases

Jamie L. Zimmerman


```
1-2-mass|normal-position|uniform-velocity|uniform-diameter|uniform.csv
10-1-mass|uniform-position|left_slanted-velocity|normal-diameter|uniform.csv
11-30-mass|uniform-position|right_slanted-velocity|uniform-diameter|_cardioid.csv
12-1-mass|right_slanted-position|uniform-velocity|right_slanted-diameter|_cardioid.csv
13-70-mass|right_slanted-position|right_slanted-velocity|uniform-diameter|left_slanted.csv
14-1-mass|left_slanted-position|normal-velocity|uniform-diameter|right_slanted.csv
15-2-mass|left_slanted-position|right_slanted-velocity|left_slanted-diameter|normal.csv
16-30-mass|normal-position|right_slanted-velocity|normal-diameter|right_slanted.csv
17-70-mass|left_slanted-position|left_slanted-velocity|normal-diameter|_cardioid.csv
18-2-mass|uniform-position|left_slanted-velocity|uniform-diameter|left_slanted.csv
19-30-mass|cardioid-position|normal-velocity|cardioid-diameter|left_slanted.csv
2-2-mass|uniform-position|right_slanted-velocity|right_slanted-diameter|right_slanted.csv
20-1-mass|uniform-position|uniform-velocity|left_slanted-diameter|normal.csv
21-2-mass|normal-position|normal-velocity|right_slanted-diameter|_cardioid.csv
22-2-mass|cardioid-position|left_slanted-velocity|cardioid-diameter|normal.csv
23-1-mass|left_slanted-position|uniform-velocity|normal-diameter|left_slanted.csv
24-1-mass|normal-position|normal-velocity|left_slanted-diameter|left_slanted.csv
25-1-mass|right_slanted-position|normal-velocity|normal-diameter|uniform.csv
26-1-mass|cardioid-position|normal-velocity|cardioid-diameter|_cardioid.csv
27-30-mass|normal-position|normal-velocity|uniform-diameter|normal.csv
28-1-mass|normal-position|normal-velocity|right_slanted-diameter|left_slanted.csv
29-1-mass|normal-position|normal-velocity|left_slanted-diameter|_cardioid.csv
3-70-mass|cardioid-position|uniform-velocity|cardioid-diameter|right_slanted.csv
4-70-mass|normal-position|left_slanted-velocity|right_slanted-diameter|normal.csv
5-2-mass|right_slanted-position|normal-velocity|normal-diameter|normal.csv
6-70-mass|uniform-position|normal-velocity|left_slanted-diameter|uniform.csv
7-30-mass|left_slanted-position|uniform-velocity|right_slanted-diameter|uniform.csv
8-30-mass|right_slanted-position|left_slanted-velocity|left_slanted-diameter|right_slanted.csv
9-1-mass|cardioid-position|right_slanted-velocity|cardioid-diameter|uniform.csv
```

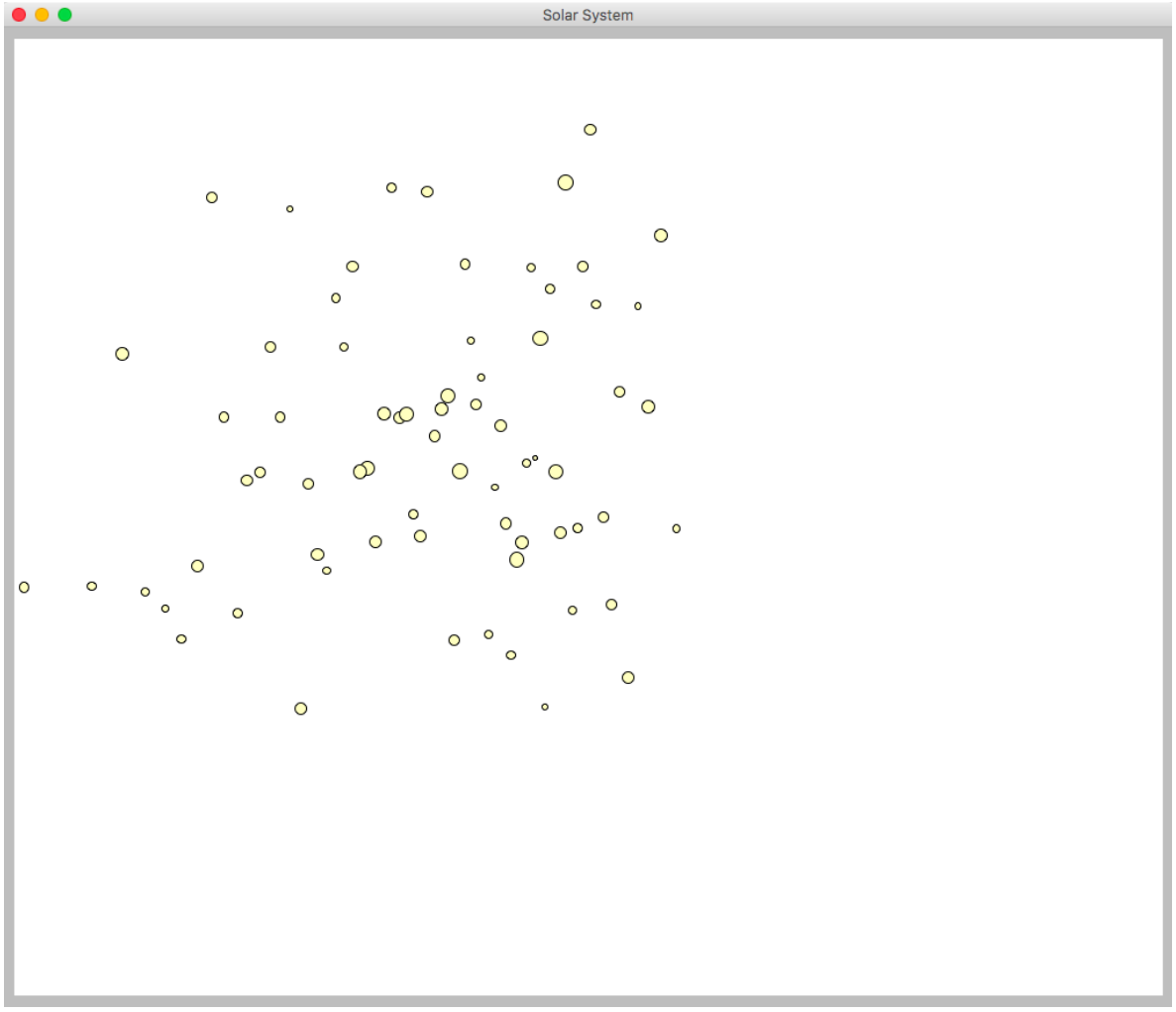
Orbits Simulation

13-70-mass|right_slanted-position|right_slanted-velocity|uniform-diameter|left_slanted.csv

- Case 13
- 70 bodies
- Mass - right-slant
- Position - right-slant
- Velocity - uniform
- Diameter - left-slant

Starting Orbits

Jamie L. Zimmerman



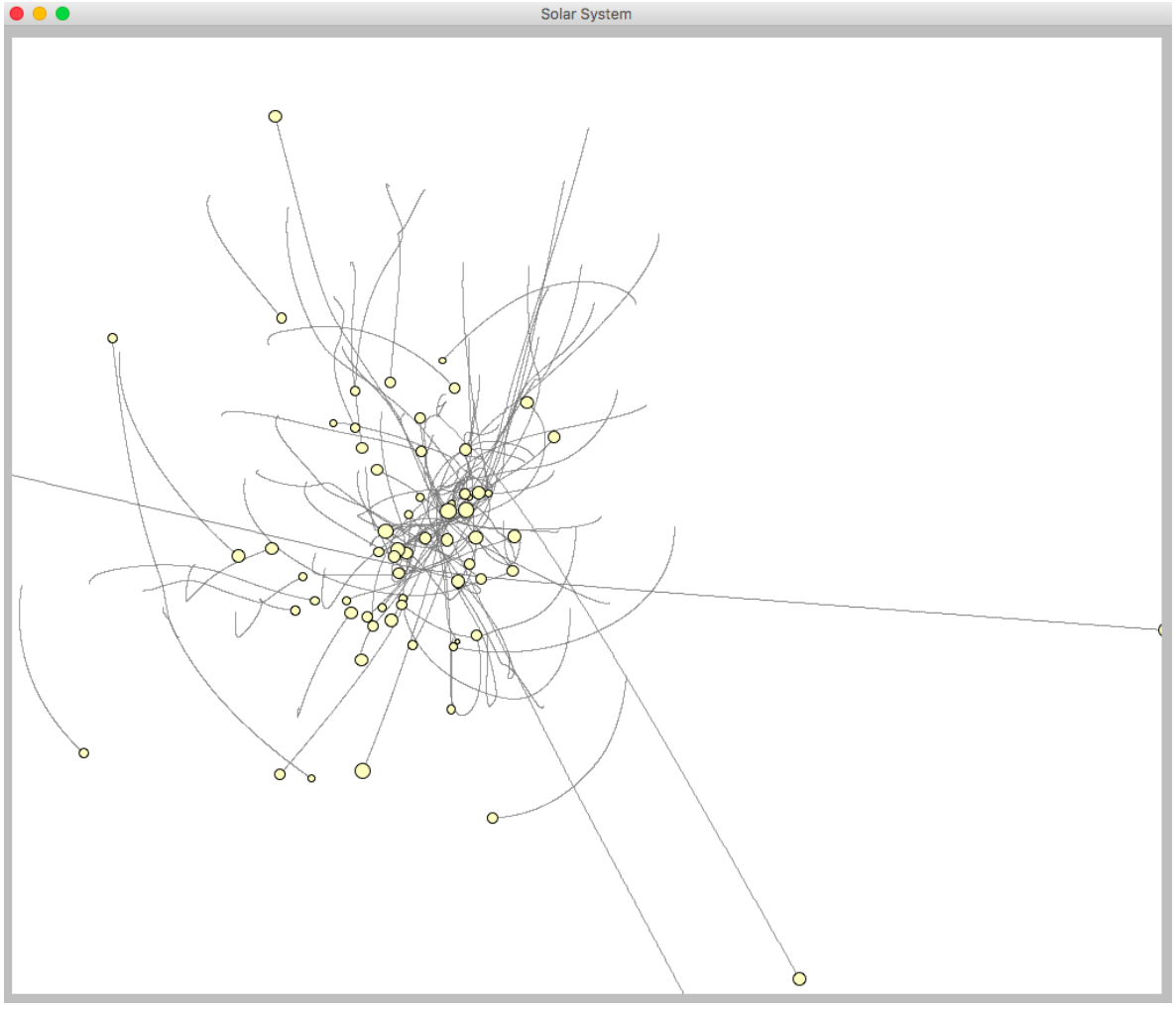
Starting Observations

- Sizes are mostly small-medium (from left-slant distribution)
- Locations are clustered (from right-slant distribution)

Ending Orbits

Jamie L. Zimmerman

665 time steps



Ending Observations

- Behavior of gravity
- Path lengths are all different (from uniform velocity)

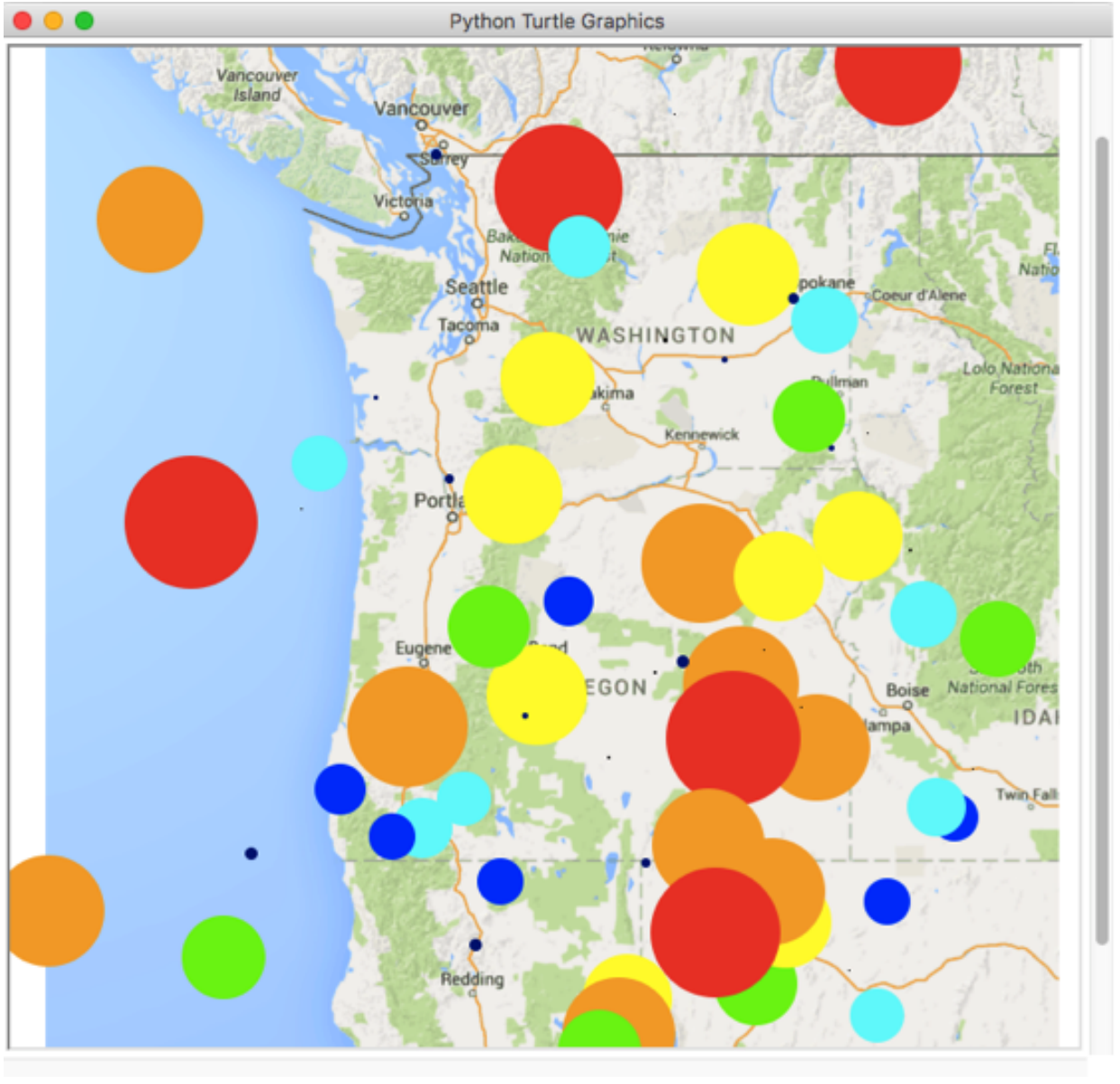
Earthquake Analysis

6-70-magnitudes|cardioid-latitudes|left_slanted-longitudes|right_slanted-depths|cardioid.csv

- Case 6
- 70 quake events
- Magnitude & Depth - Cardioid relationship
- Trend: High Magnitude $\rightarrow$ High Depth
- Low Magnitude $\rightarrow$ Low Depth
- Latitudes - left-slant
- Longitudes - right-slant

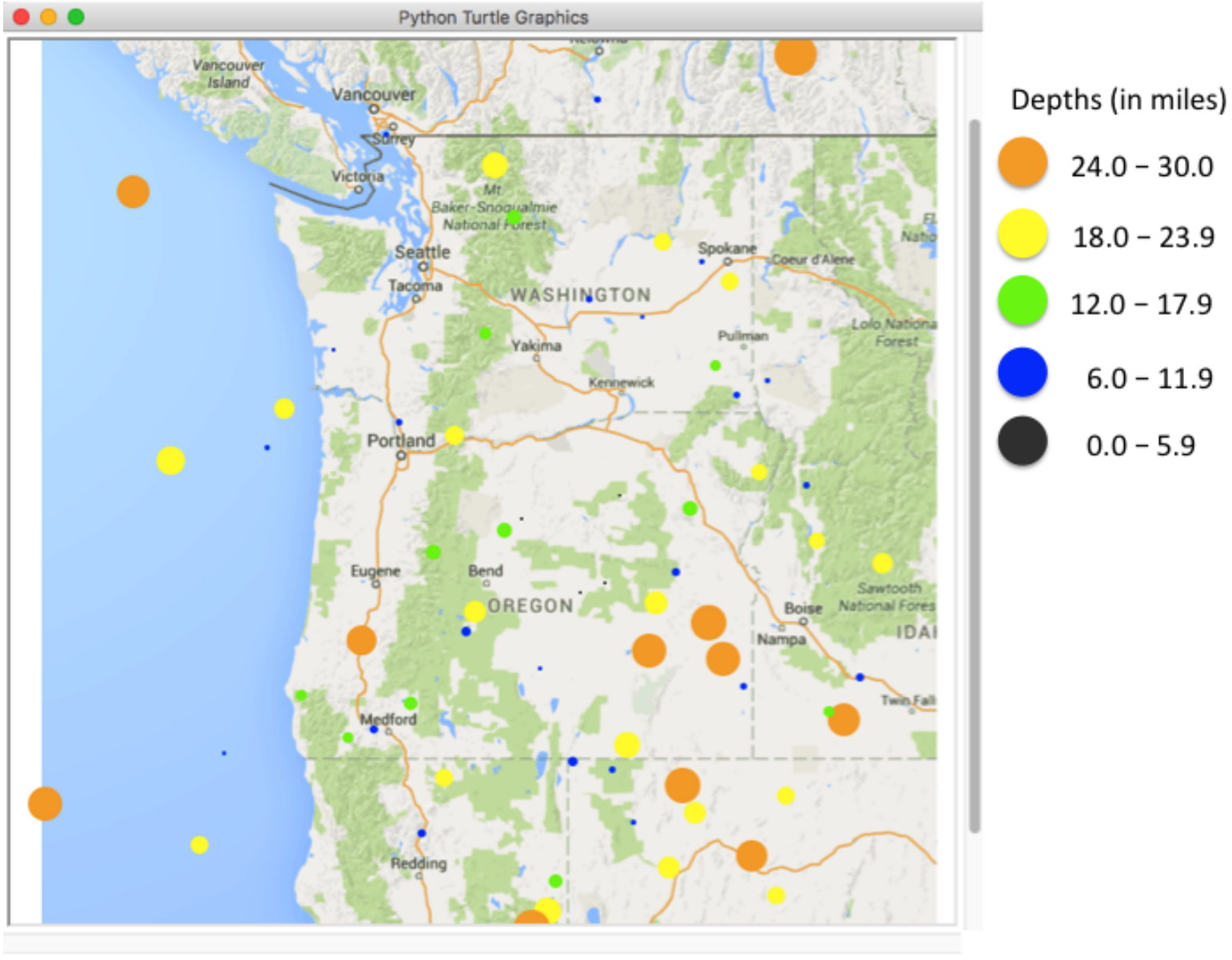
Magnitudes & Depths

Jamie L. Zimmerman



Magnitudes & **Depths**

Jamie L. Zimmerman

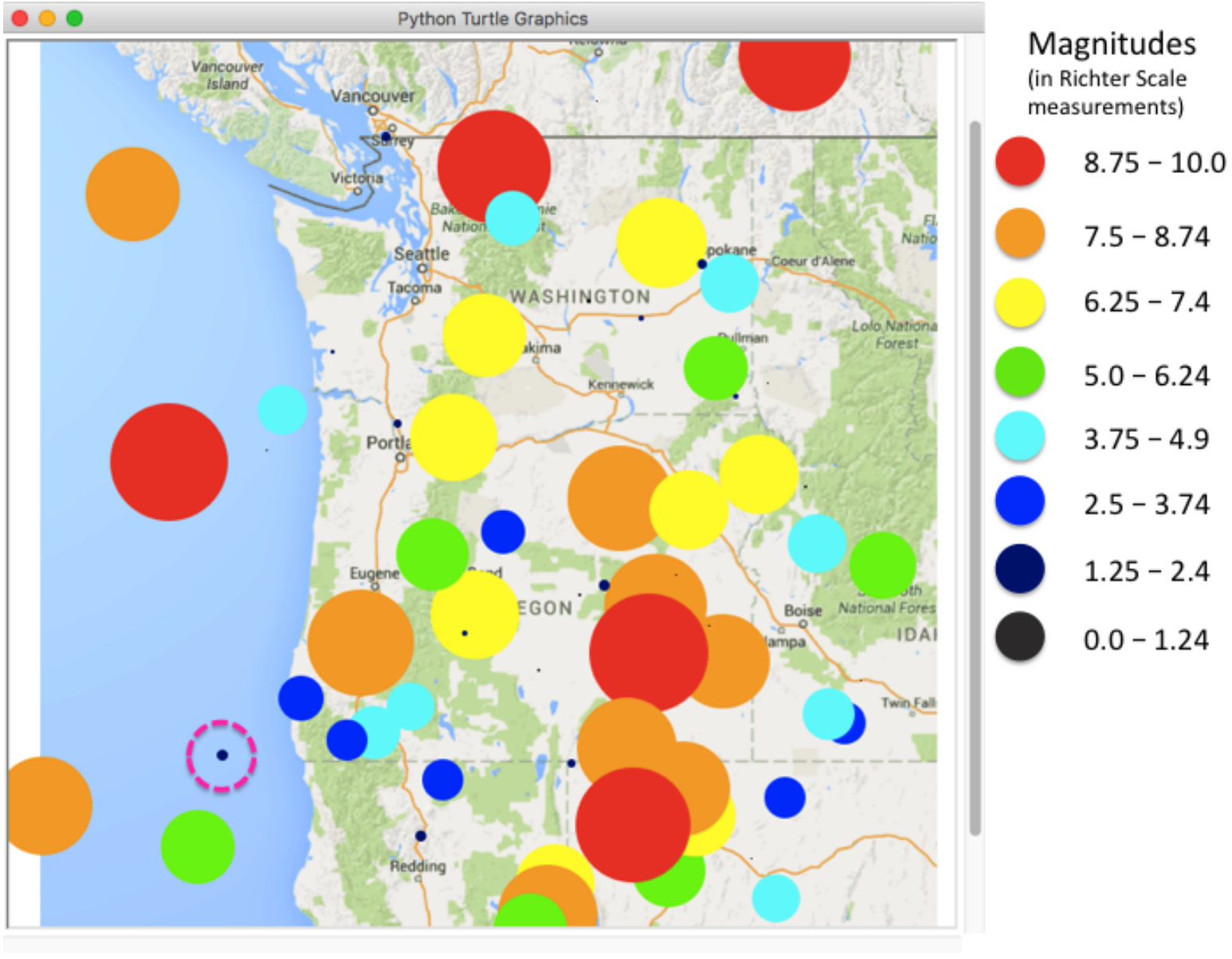


Observations

- Mostly predicted events?
- Any outliers?

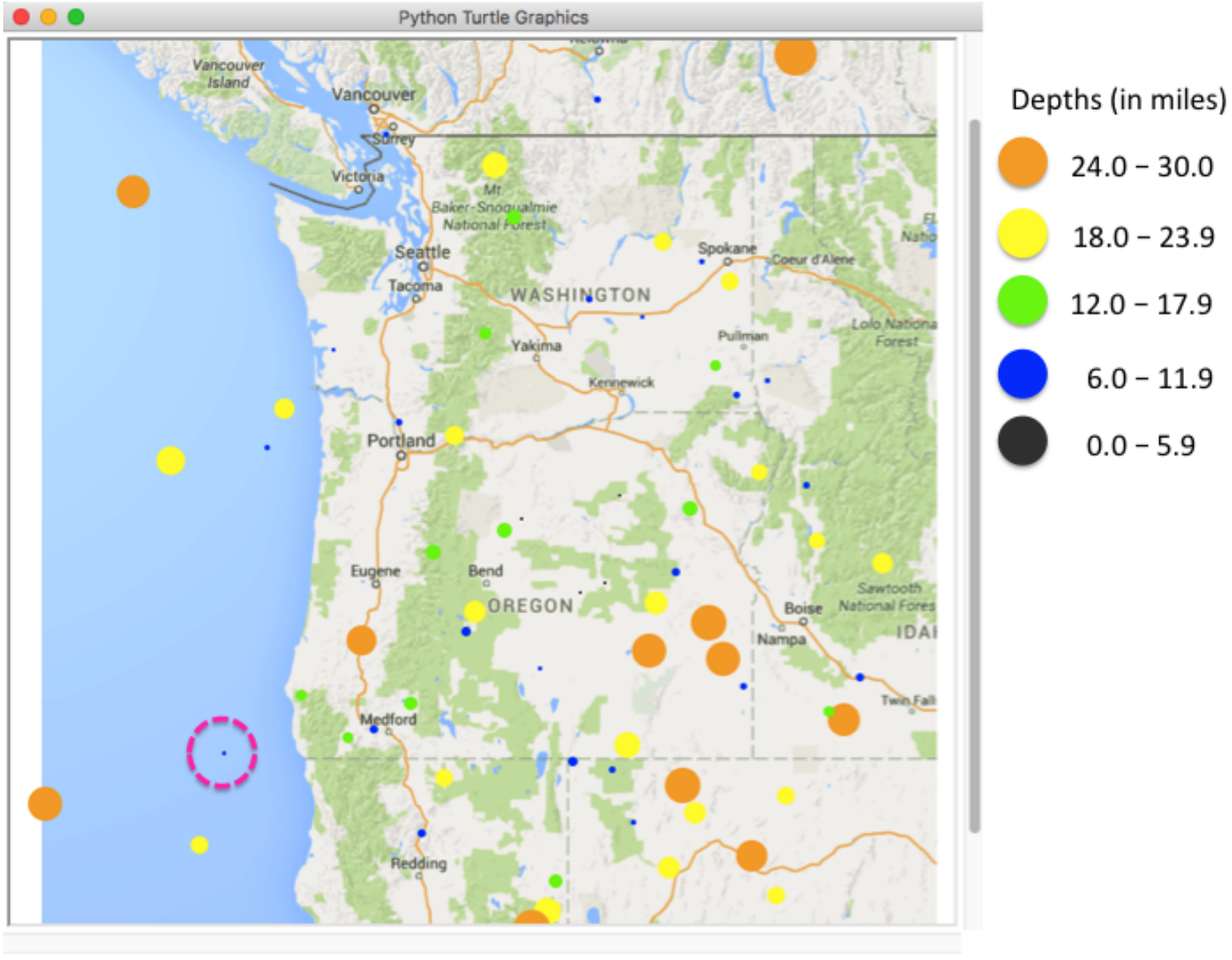
Magnitudes & Depths Frequent Occurrence

Jamie L. Zimmerman



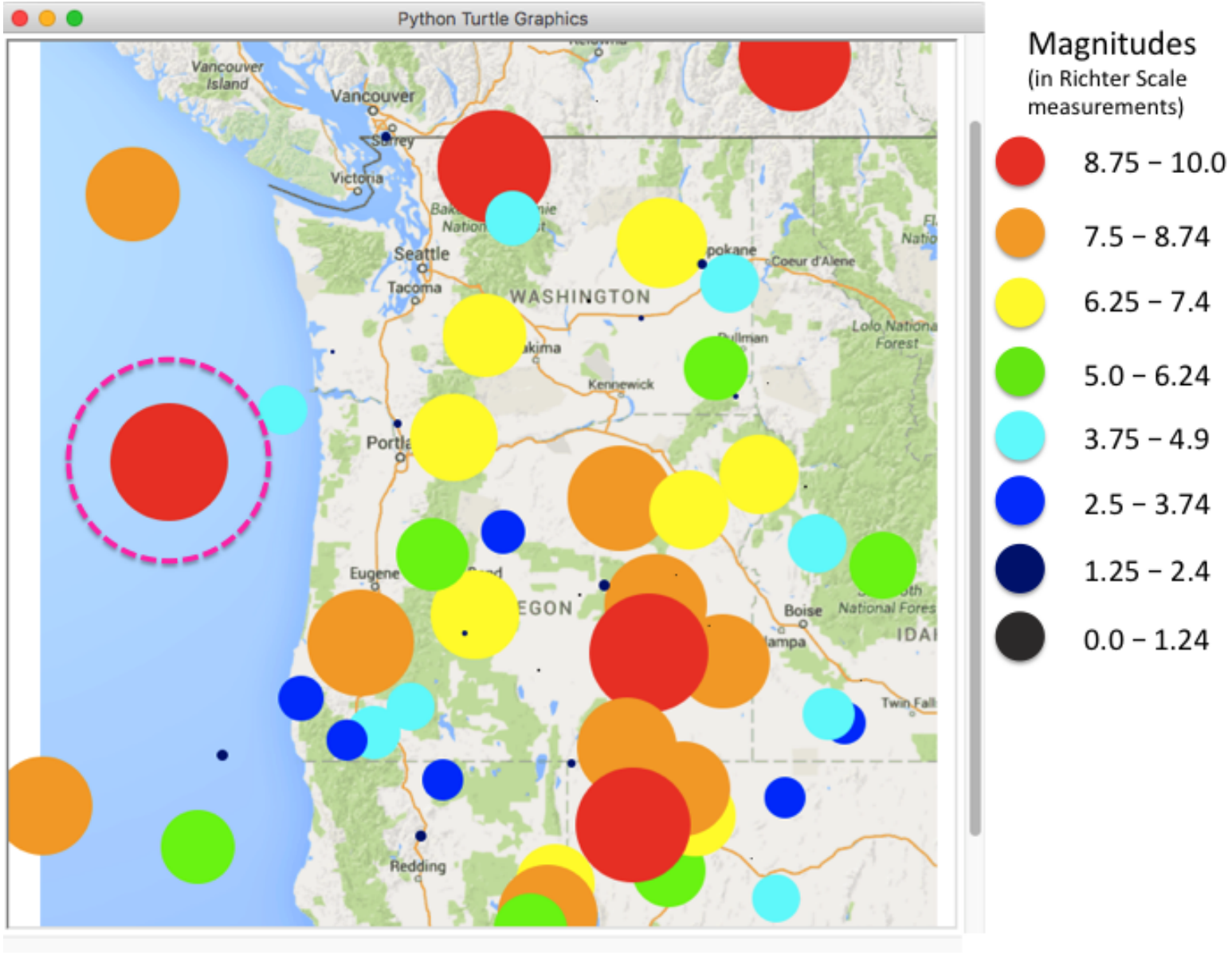
Magnitudes & **Depths** Frequent Occurence

Jamie L. Zimmerman



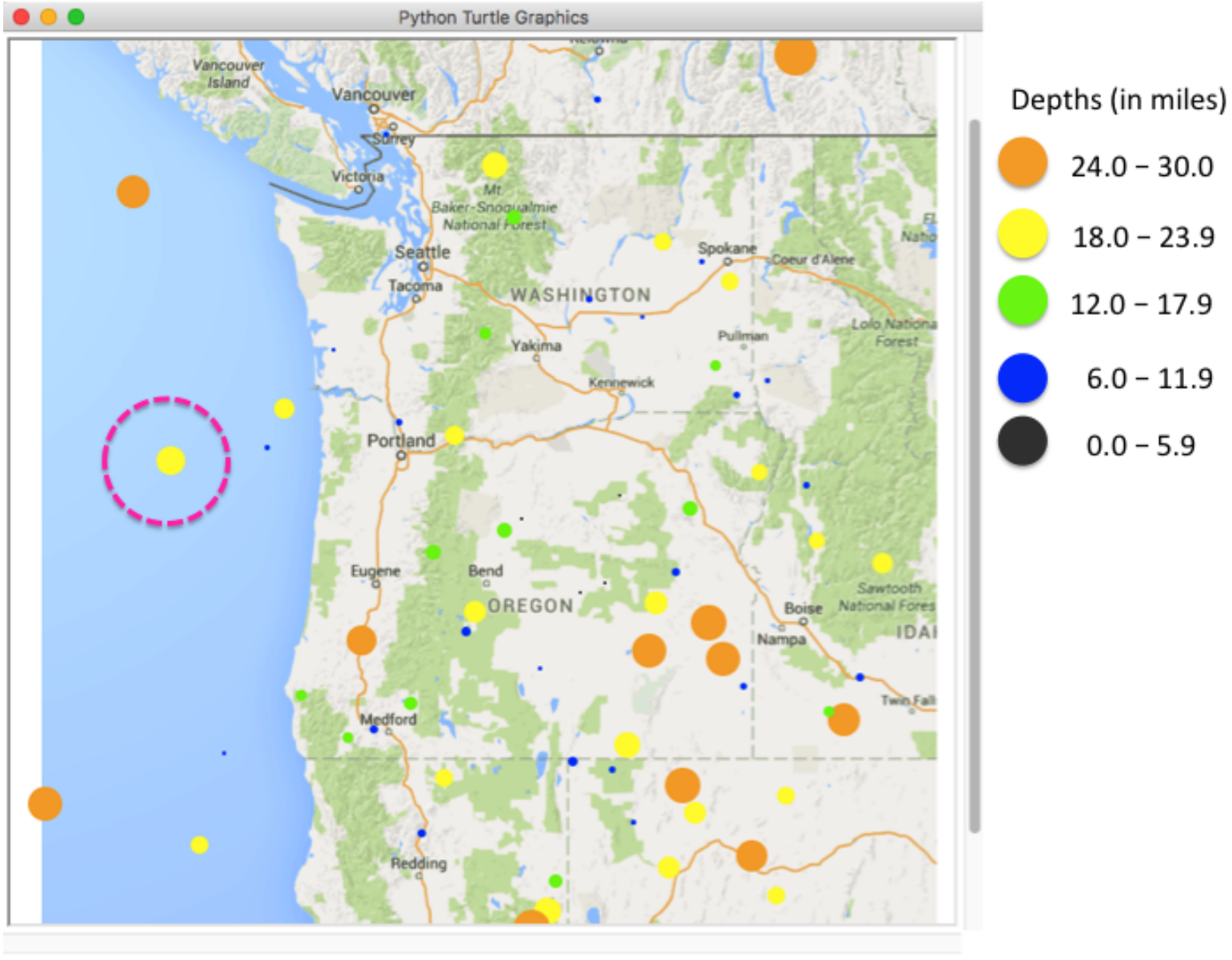
Magnitudes & Depths Frequent Occurrence

Jamie L. Zimmerman



Magnitudes & **Depths** Frequent Occurence

Jamie L. Zimmerman



Magnitudes & Depths Outlier

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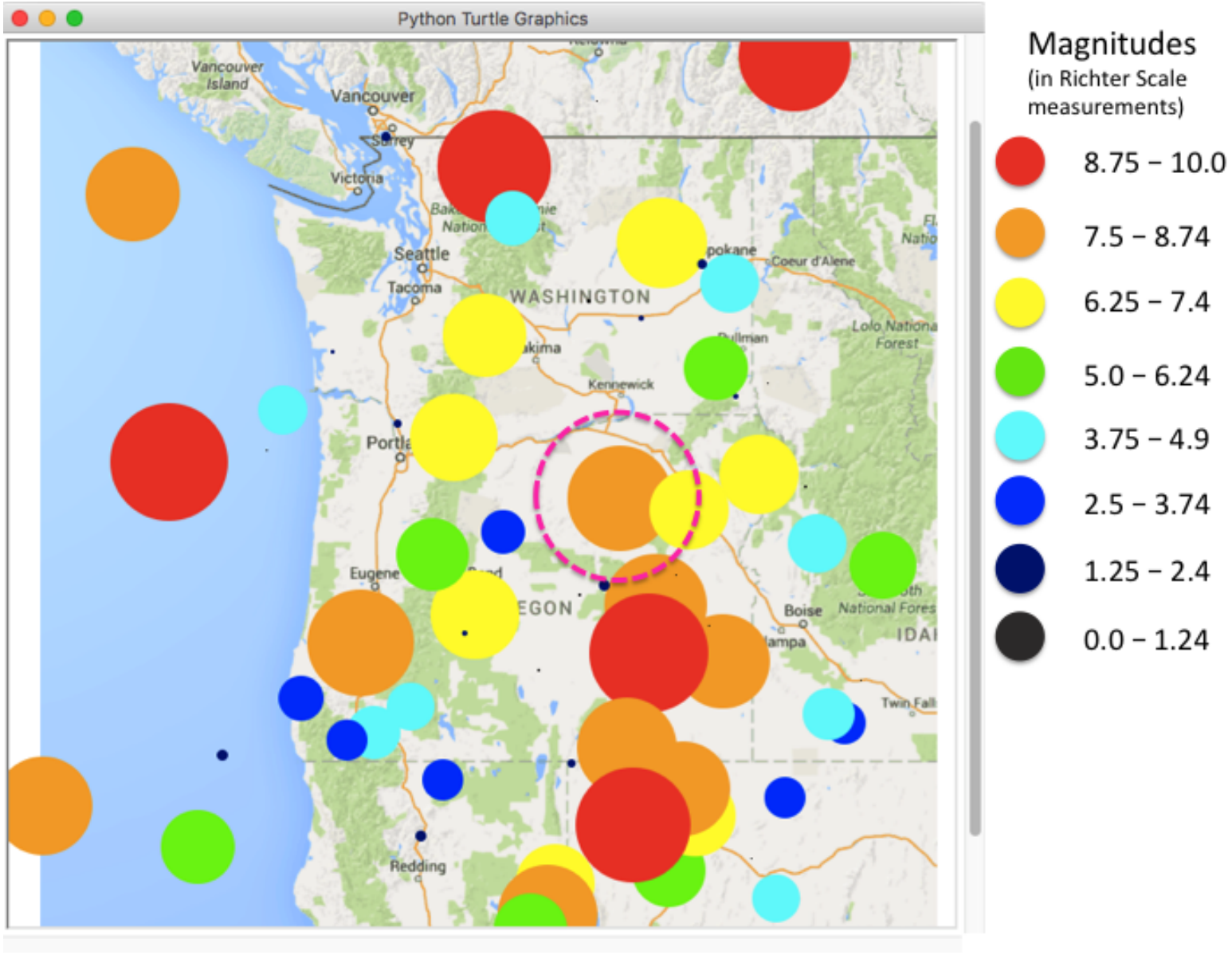
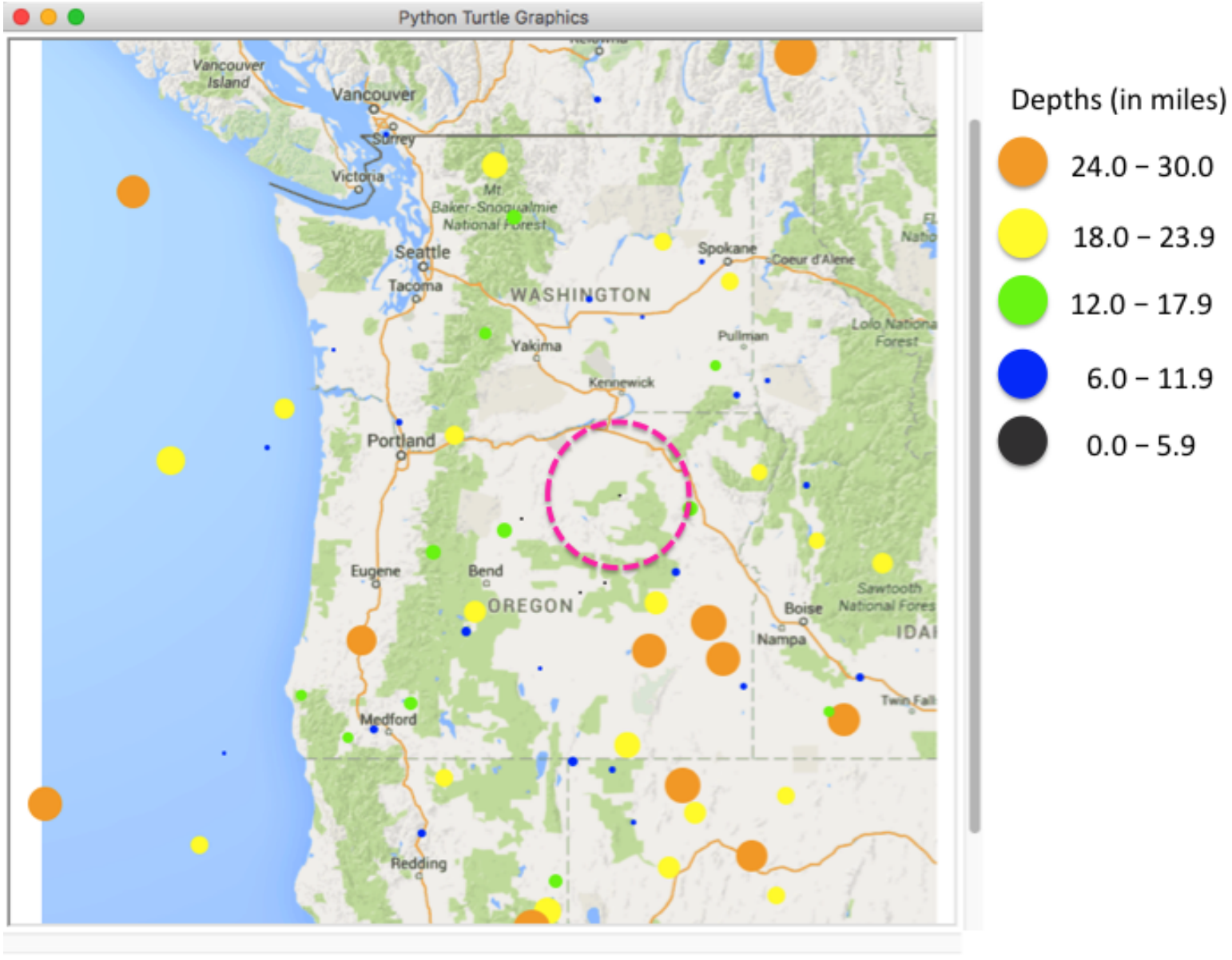


Magnitudes & **Depths** Outlier

Jamie L. Zimmerman

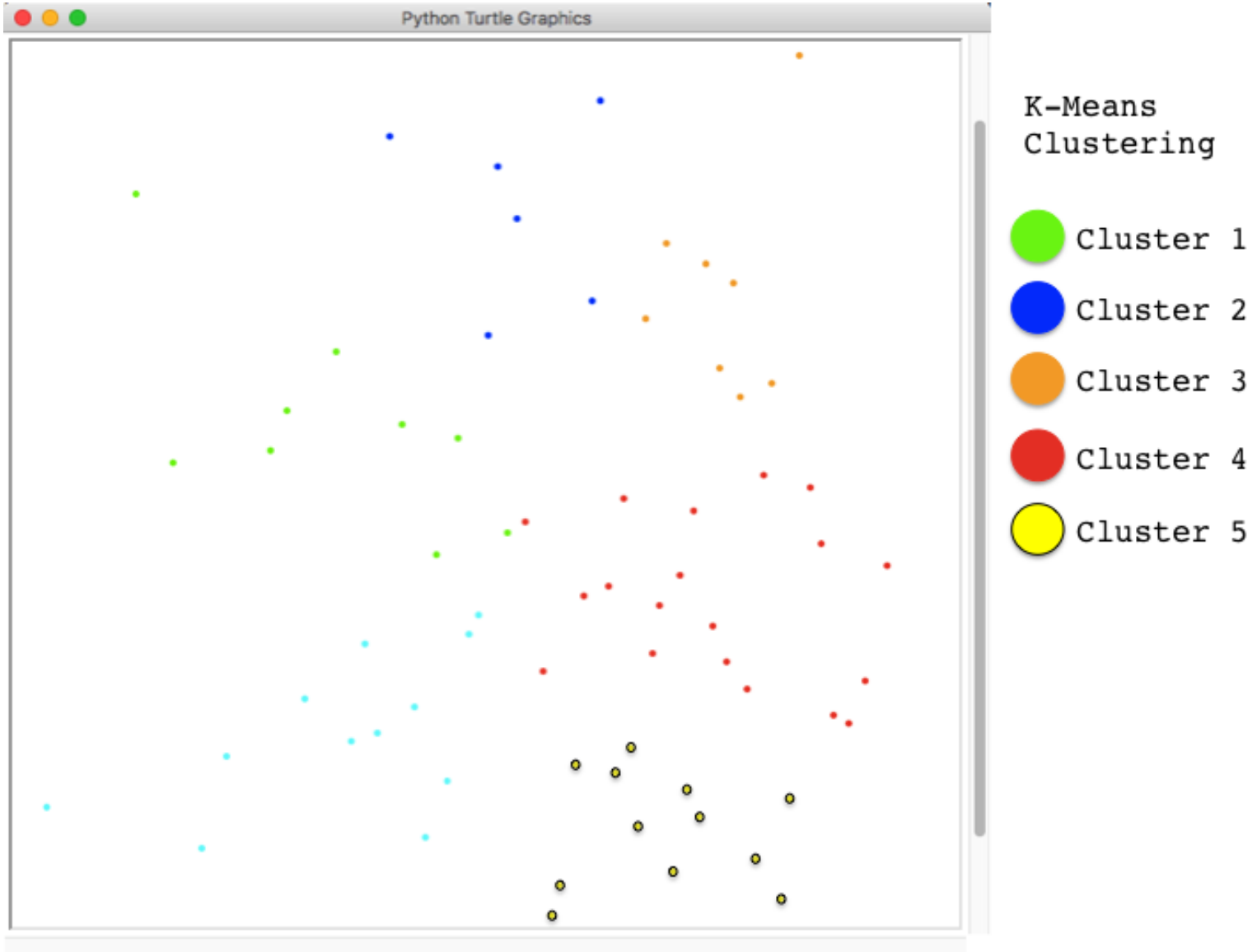


Predict

- North - Up
- West - Left
- East - Right
- South - Down
- right-slanted is high numbers
- left-slanted is low numbers
- right-leaning longitudes
- left-leaning latitudes
- Quakes drift towards lower-right corner

Latitudes & Longitudes

Jamie L. Zimmerman



Overview

GenSequence in all its Power

- It is what it says it is
- Nearly end-to-end automation
- Knowing about input informs the expected output?

Future Work

- Test GenSequence against an open-source project
- Combine user-written spec files
- Machine Learning Models
- Database-Driven Applications

Citations

- Robins, Annabel. Software Testing and QA: Theory of Practice. Univeristy of Waterloo: Naik and Tripathy, 2009. http://slideplayer.com/slide/5946428/20/images/10/Pairwise+Testing+Handouts.+The+total+number+combination+test+cases+is+2+%C3%97+2+%C3%97+2+=+8..jpg
- N. G. Leveson and C. S. Turner. 1993. An Investigation of the Therac-25 Accidents. Computer 26, 7 (July 1993), 18-41. DOI: https://doi.org/10.1109/MC.1993.274940
- Klein, Dave. "The Scientific Method." Brooklyn College BIOL 1010 : Lab Notes. Brooklyn College, 2016.