Data Cleaning

February 12, 2019
Data Science CSCI 1951A
Brown University
Instructor: Ellie Pavlick
HTAs: Wennie Zhang, Maulik Dang, Gurnaaz Kaur

[1] Thanks to C. Binning for some stolen slides. :)

A message from your Health and Wellness Advocates!

- Health and Wellness Resource Fair - Feb 20 (Wed), 4-6PM, CIT 1st Floor Atrium

- Open Hours! wellness.advocates@lists.brown.edu

Announcements

- A message from your Health and Wellness Advocates!
- iClicker syncing—the saga continues
- Collab policy… … .. .
- Final project teaming—fill out the form please!

Announcements

COLLABORATION POLICY!

Announcements

COLLABORATION POLICY!

SERIOUSLY, PEOPLE.....

Today

- Problems with dirty data
- Cleaning and string matching heuristics
- Bash commands—greatest hits (for data scientists)

ID	Name	Street	City	State	Zip	Hours
1	J Meltzer	123 University Ave	Providence	RI	98106	42
2	Erin Bugbee	245 3rd St	Pawtucket	RI	98052-1234	30
3	David Wang	345 Broadway	PVD	Rhode Island	98101	19
4	E Bugbe	245 Third Street	Pawtucket	NULL	98052	299
5	Dave Wang	345 Broadway St	Providnce	Rhode Island	98101	19
6	Jacob Meltzer	123 Univ Ave	PVD	Rhode Island	NULL	41
7	Haomo Ni	123 University Ave	Providence	Guyana	94305	NULL

…

Problems?

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Inconsistent Representations

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Missing Values

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Typos

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Duplicates

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Maybe Duplicates?

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- Data doesn't "age well" (inflation, restricting)
- Any combination of the above

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- Naming conventions: NYC vs New York
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- Fields too long (get truncated)
- Primary key violations (from data merging)

Dirty Data…

- Parsing input data (e.g., separator issues)
- Naming conventions: NYC vs New York
- Formatting issues – esp. dates
- Missing values and required fields (e.g., always use 0)
- Different representations (2 vs Two)
- Fields too long (get truncated)
- Primary key violations (from data merging)
- Redundant Records (from data merging)

Clicker Lightening Round!

TAS

ID	Name	City	State	Hours
1	J Meltzer	Providence	RI	42
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7	Haomo Ni	Warwick	RI	NULL

ID	Name	City	State	Hours
1	J Meltzer	Providence	Rhode Island	42
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How will the dirty data affect the results of this query?

(a) Too high

(b) Too low

(c) Unaffected

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How many TAs are there?

```
SELECT COUNT(*)
FROM TAS
```

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TAS

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Duplicates -> Double Counting

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How will the dirty data affect the results of this query?

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How many TAs have worked zero hours?

```
SELECT COUNT(*)
FROM TAS
WHERE Hours = 0
```

Clicker Lightening Round!

TAS

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NULLS aren't included in the where clause

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How many hours do my commuter TAs work?

```
SELECT SUM(Hours)
FROM TAS
WHERE City != "Providence"
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Clicker Lightening Round!

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Inconsistent names, typos, and duplicates...

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Look at your data

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FROM PEOPLE
GROUP BY Zip_Code
ORDER BY pop
```

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City	Count(*)
Schenectady	2,500
New York City	2,200
Los Angeles	1,900
Dallas	1,400

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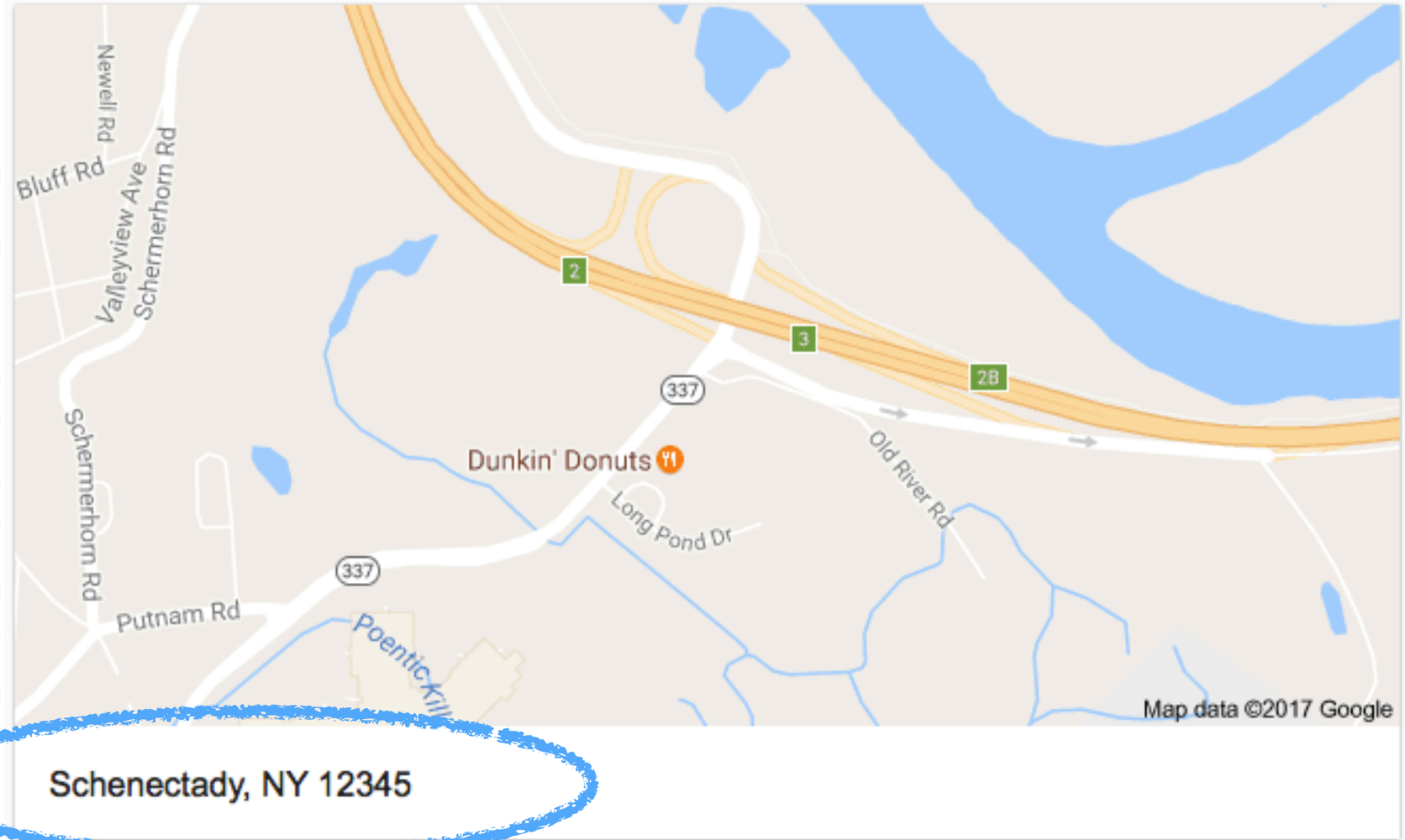
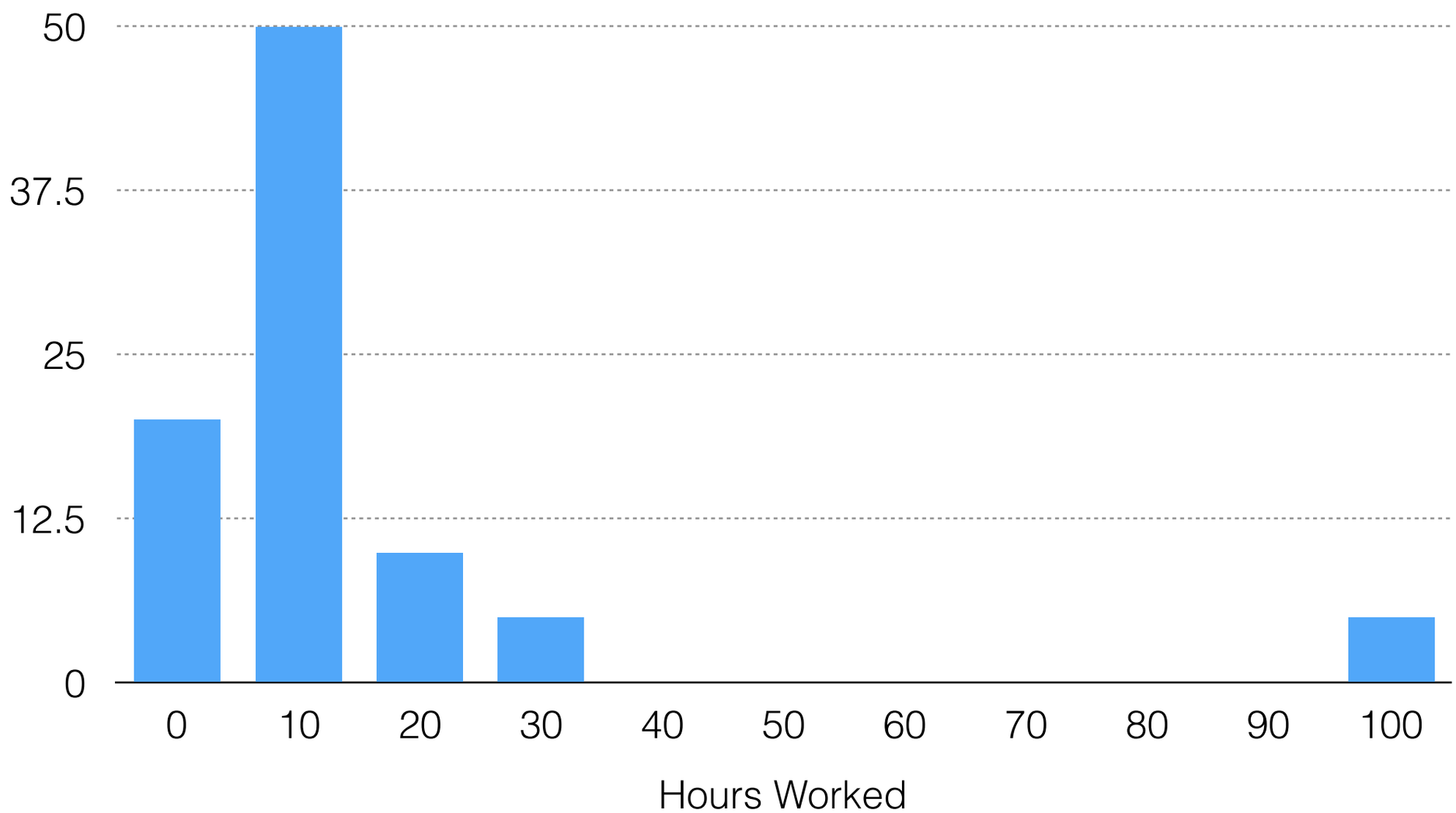
Loc

```
SELECT (
FROM PE(
GROUP B
ORDER B
```

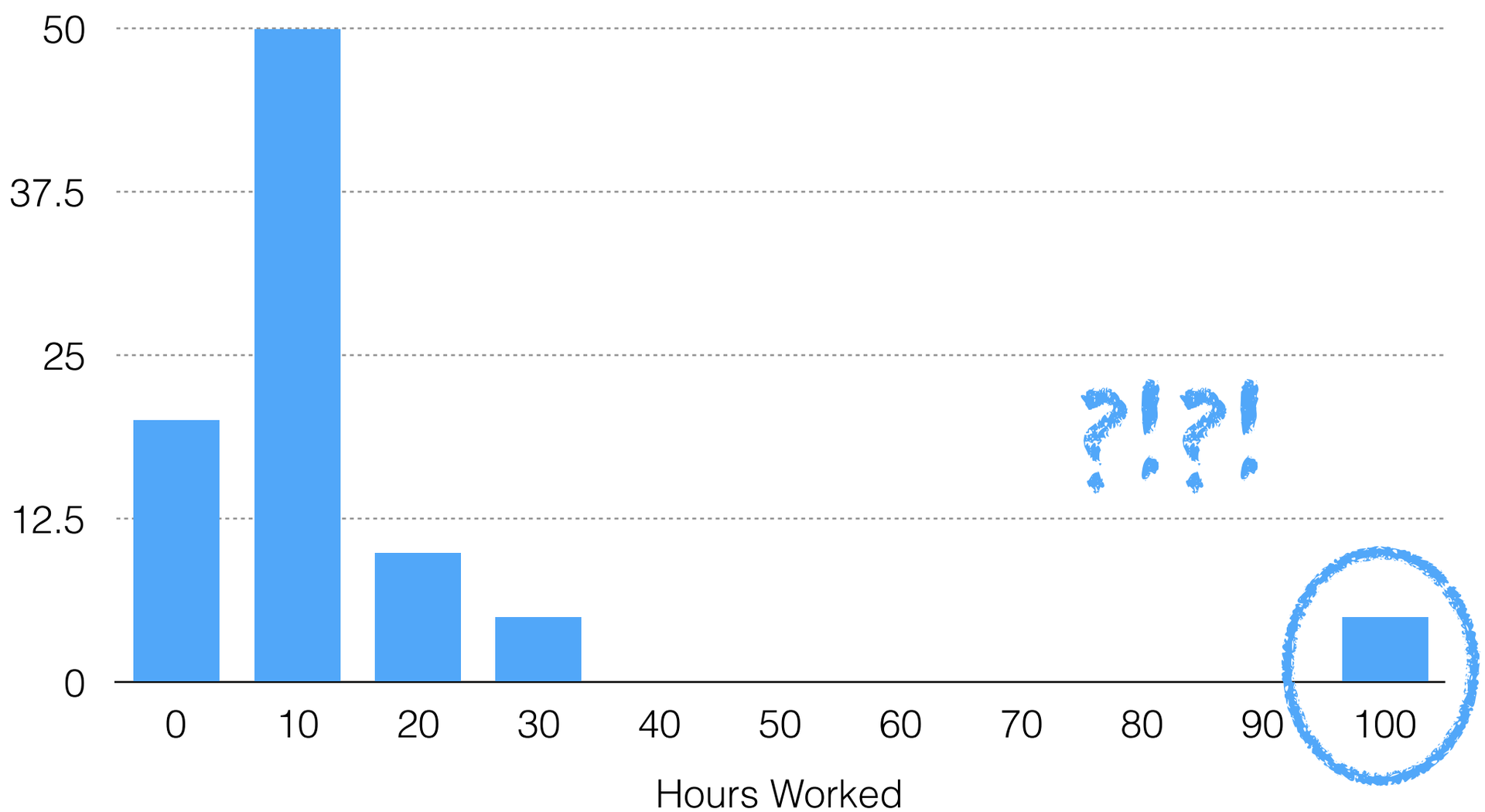


City	Count(*)
12345	2,500
10001	2,2000
90001	1,900
75001	1,400

Set Defaults/Remove Outliers



Set Defaults/Remove Outliers



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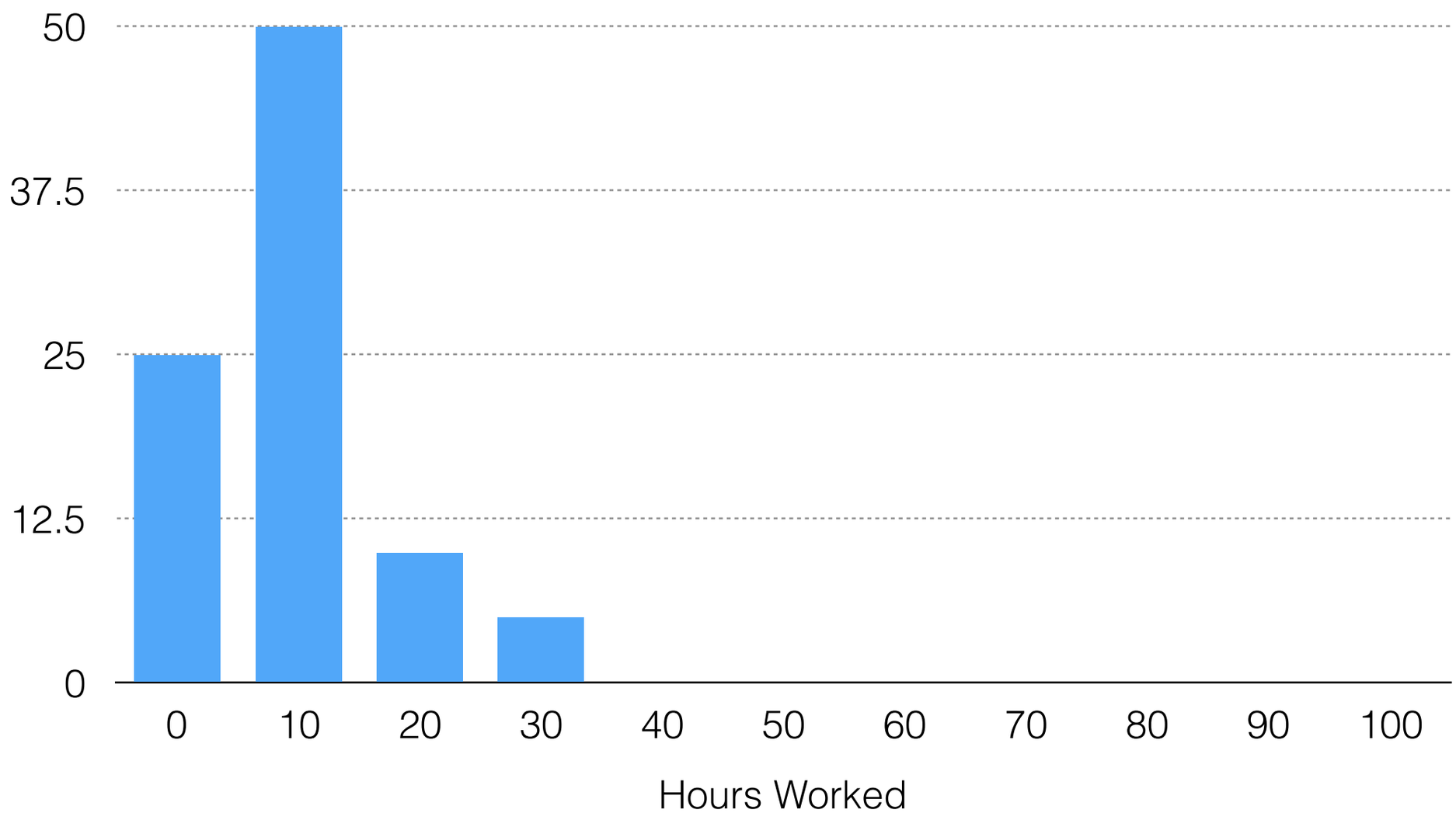

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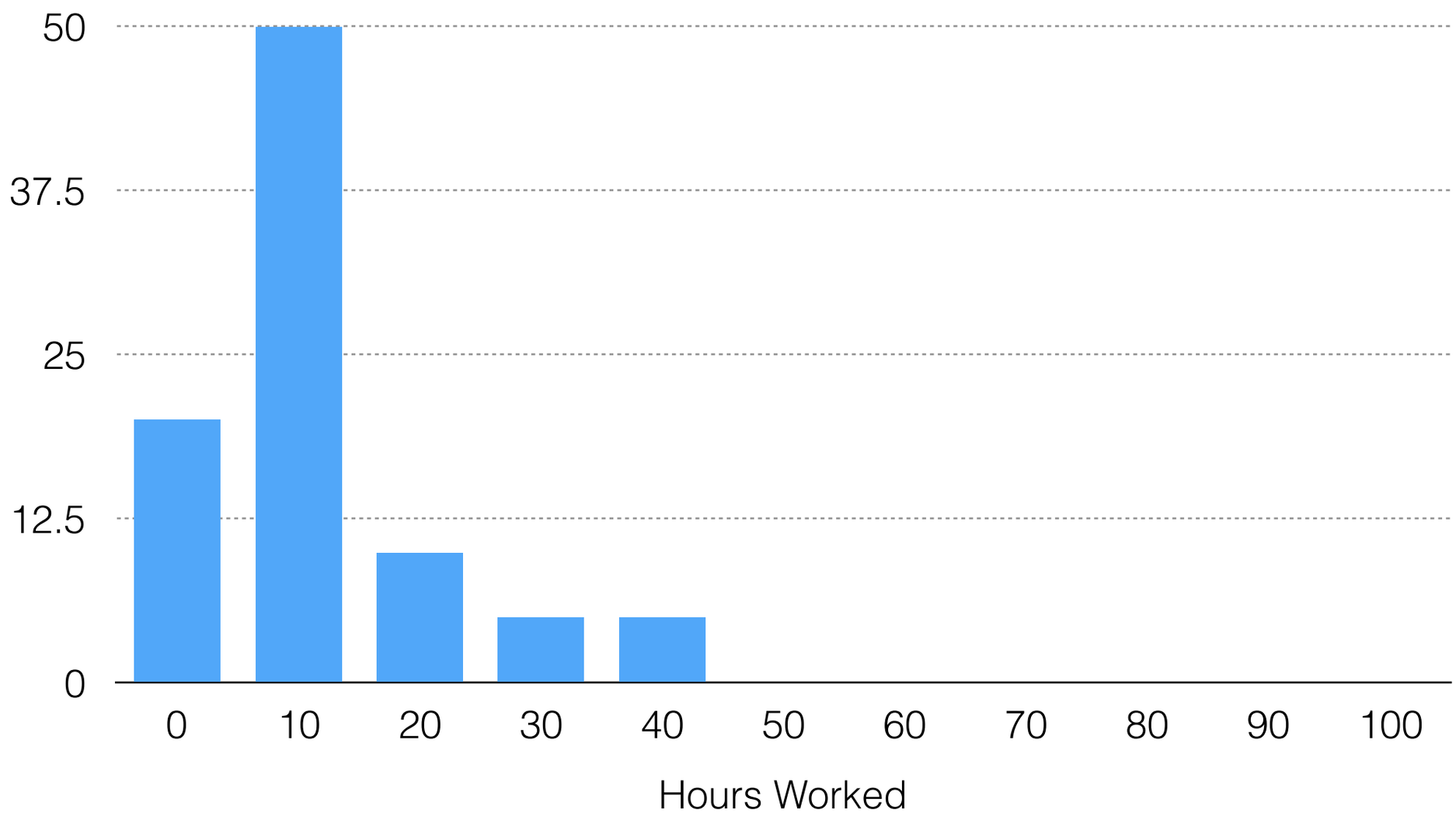

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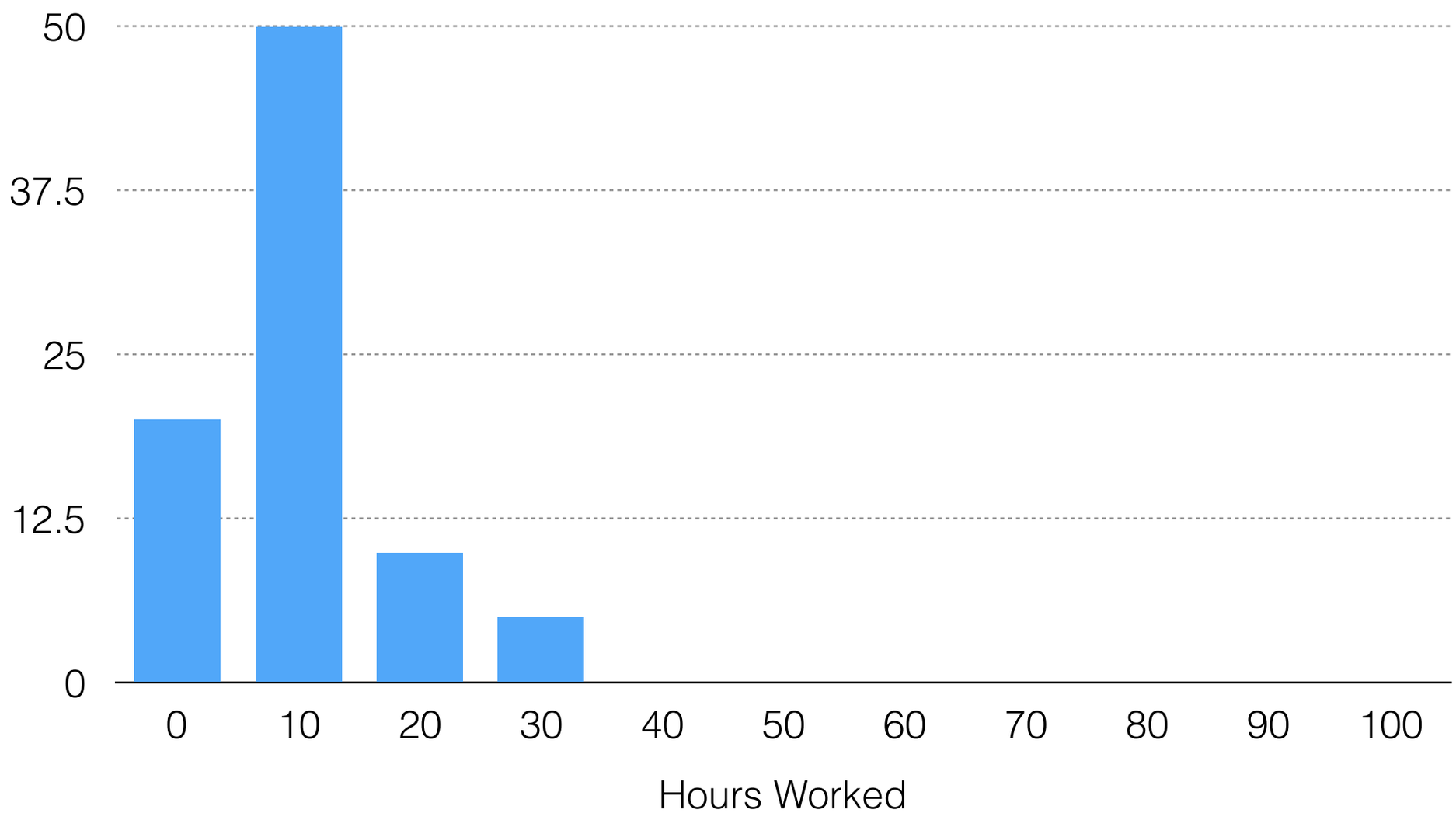

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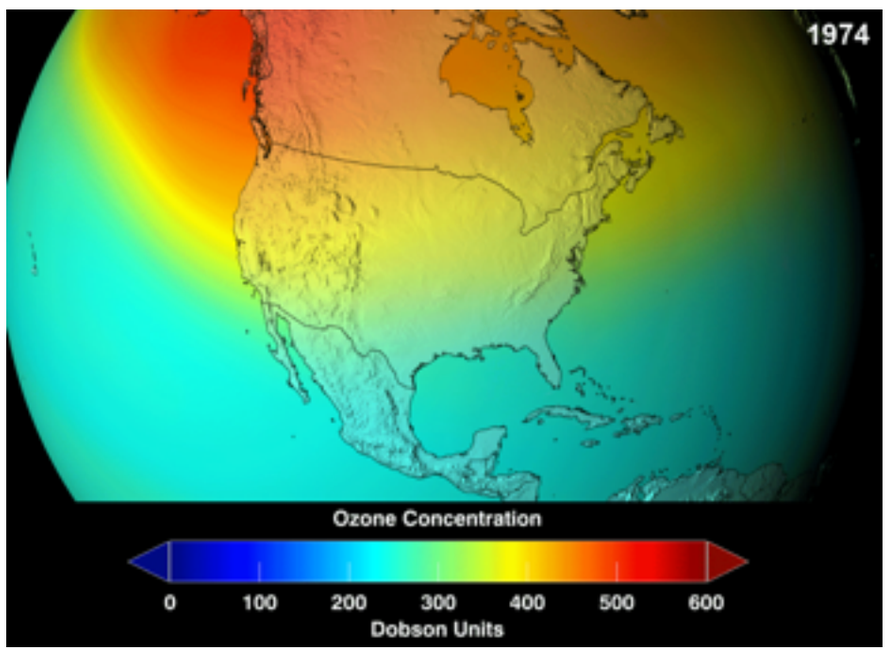
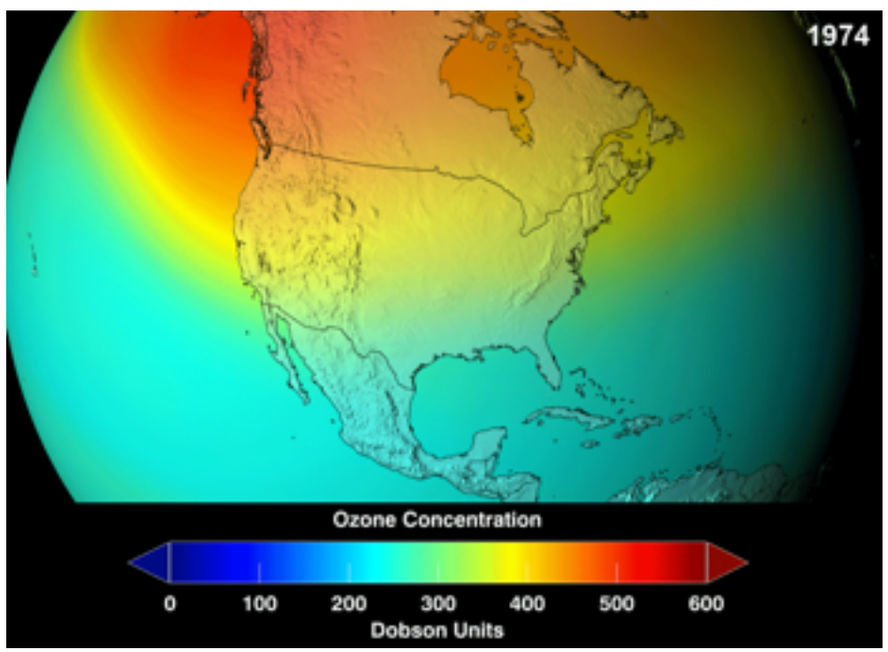


The discovery of the Antarctic "ozone hole" by British Antarctic Survey scientists Farman, Gardiner and Shanklin…came as a shock to the scientific community…[The data] were initially rejected as unreasonable by data quality control algorithms (they were filtered out as errors since the values were unexpectedly low); the ozone hole was detected only in satellite data when the raw data was reprocessed following evidence of ozone depletion in in situ observations. When the software was rerun without the flags, the ozone hole was seen as far back as 1976.

https://en.wikipedia.org/wiki/Ozone_depletion#Antarctic_ozone_hole

Set Defaults/Remove Outliers



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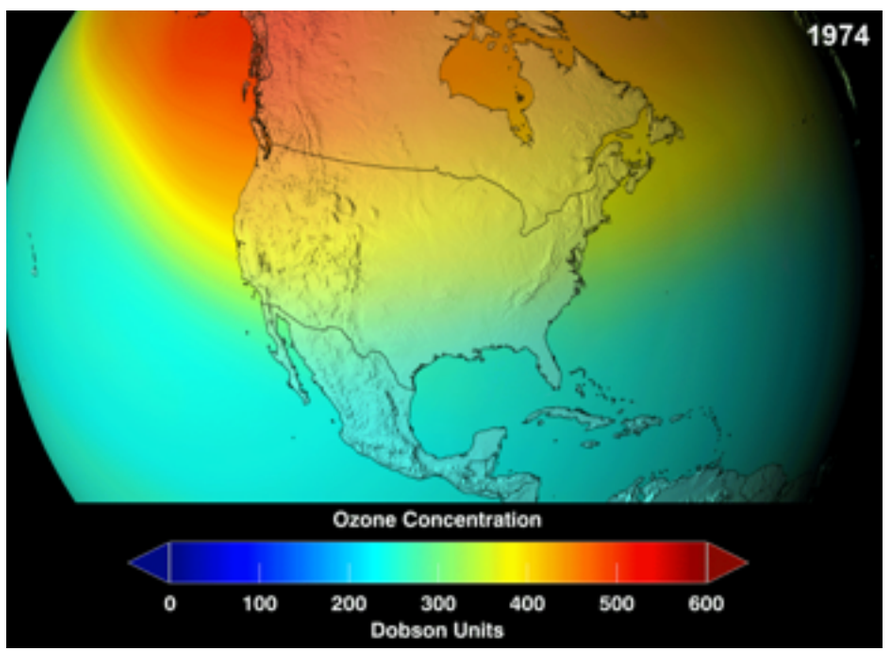

Always always always! Look at the data!

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https://en.wikipedia.org/wiki/Ozone_depletion#Antarctic_ozone_hole

String Similarity

String Similarity: Edit Distance

Minimal number of edits (inserts, deletes, substitutions) needed to transform A into B.

https://en.wikipedia.org/wiki/Levenshtein_distance

String Similarity: Edit Distance

$$d_{i0} = \sum_{k=1}^{i} w_{\text{del}}(b_k), \qquad \text{for } 1 \le i \le m$$

$$d_{0j} = \sum_{k=1}^{j} w_{\text{ins}}(a_k), \qquad \text{for } 1 \le j \le n$$

$$d_{ij} = \begin{cases} d_{i-1,j-1} & \text{for } a_j = b_i \\ \min \begin{cases} d_{i-1,j} + w_{\text{del}}(b_i) \\ d_{i,j-1} + w_{\text{ins}}(a_j) \\ d_{i-1,j-1} + w_{\text{sub}}(a_j, b_i) \end{cases} & \text{for } a_j \ne b_i \end{cases} \qquad \text{for } 1 \le i \le m, 1 \le j \le n.$$

https://en.wikipedia.org/wiki/Levenshtein_distance

String Similarity: Edit Distance

115th Waterman St., Providence, RI

110th Waterman St., Providence, RI

EditDistance = 1

String Similarity: Edit Distance

Waterman Street, Providence, RI

Waterman St, Providence, RI

EditDistance = 4

String Similarity: Edit Distance

Problems?

String Similarity: Edit Distance

148th Ave NE, Redmond, WA

148th Ave NE, Redmond, WA

String Similarity: Edit Distance

Edit Distance = 0

148th Ave NE, Redmond, WA

148th Ave NE, Redmond, WA

String Similarity: Edit Distance

Edit Distance = 0

148th Ave NE, Redmond, WA

148th Ave NE, Redmond, WA

148th Ave NE, Redmond, WA

NE 148th Ave, Redmond, WA

String Similarity: Edit Distance

Edit Distance = 0

148th Ave NE, Redmond, WA

148th Ave NE, Redmond, WA

148th Ave NE, Redmond, WA

NE 148th Ave, Redmond, WA

Edit Distance = 4

String Similarity: Jaccard Similarity

$$J(A, B) = \frac{|A \cap B|}{|A \cup B|}$$

https://en.wikipedia.org/wiki/Jaccard_index

String Similarity: Jaccard Similarity

148th Ave NE, Redmond, WA

140th Ave NE, Redmond, WA

https://en.wikipedia.org/wiki/Jaccard_index

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148th Ave NE, Redmond, WA

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148th Ave NE, Redmond, WA

140th Ave NE, Redmond, WA

Jaccard = 4 / 6 = .67

https://en.wikipedia.org/wiki/Jaccard_index

String Similarity: Jaccard Similarity

148th Ave NE, Redmond, WA

NE 148th Ave, Redmond, WA

Jaccard = ???

https://en.wikipedia.org/wiki/Jaccard_index

String Similarity: Jaccard Similarity

148th Ave NE, Redmond, WA

NE 148th Ave, Redmond, WA

Jaccard = 1

https://en.wikipedia.org/wiki/Jaccard_index

Clicker Question!

iPad Two 16GB WiFi White

iPad 2nd generation 16GB WiFi White

What's the Jaccard Similarity?

(a) 3/8

(b) 4/11

(c) 4/7

Clicker Question!

iPad Two 16GB WiFi White

iPad 2nd generation 16GB WiFi White

What's the Jaccard Similarity?

(a) 3/8

(b) 4/11

(c) 4/7

$$\frac{\#(\text{iPad, 16GB, Wifi, White})}{\#(\text{iPad, Two, 2nd, generation, 16GB, Wifi, White})}$$

String Similarity: Jaccard Similarity

Michigan State University

Michigan State Univ.

Michigan State University

Ohio State University

https://en.wikipedia.org/wiki/Jaccard_index

String Similarity: Jaccard Similarity

Jaccard = 0.5

Michigan State University

Michigan State Univ.

Jaccard = 0.5

Michigan State University

Ohio State University

https://en.wikipedia.org/wiki/Jaccard_index

String Similarity: (Weighted) Jaccard Similarity

Jaccard = 0.5

3

Michigan 1 State 1 University

Michigan State Univ.

Jaccard = 0.25

Michigan State University

Ohio State University

https://en.wikipedia.org/wiki/Jaccard_index

String Similarity: (Weighted) Jaccard Similarity

Jaccard = 0.5

3

Michigan 1 State 1 University

Michigan State Univ.

Jaccard = 0.5

Michigan State University

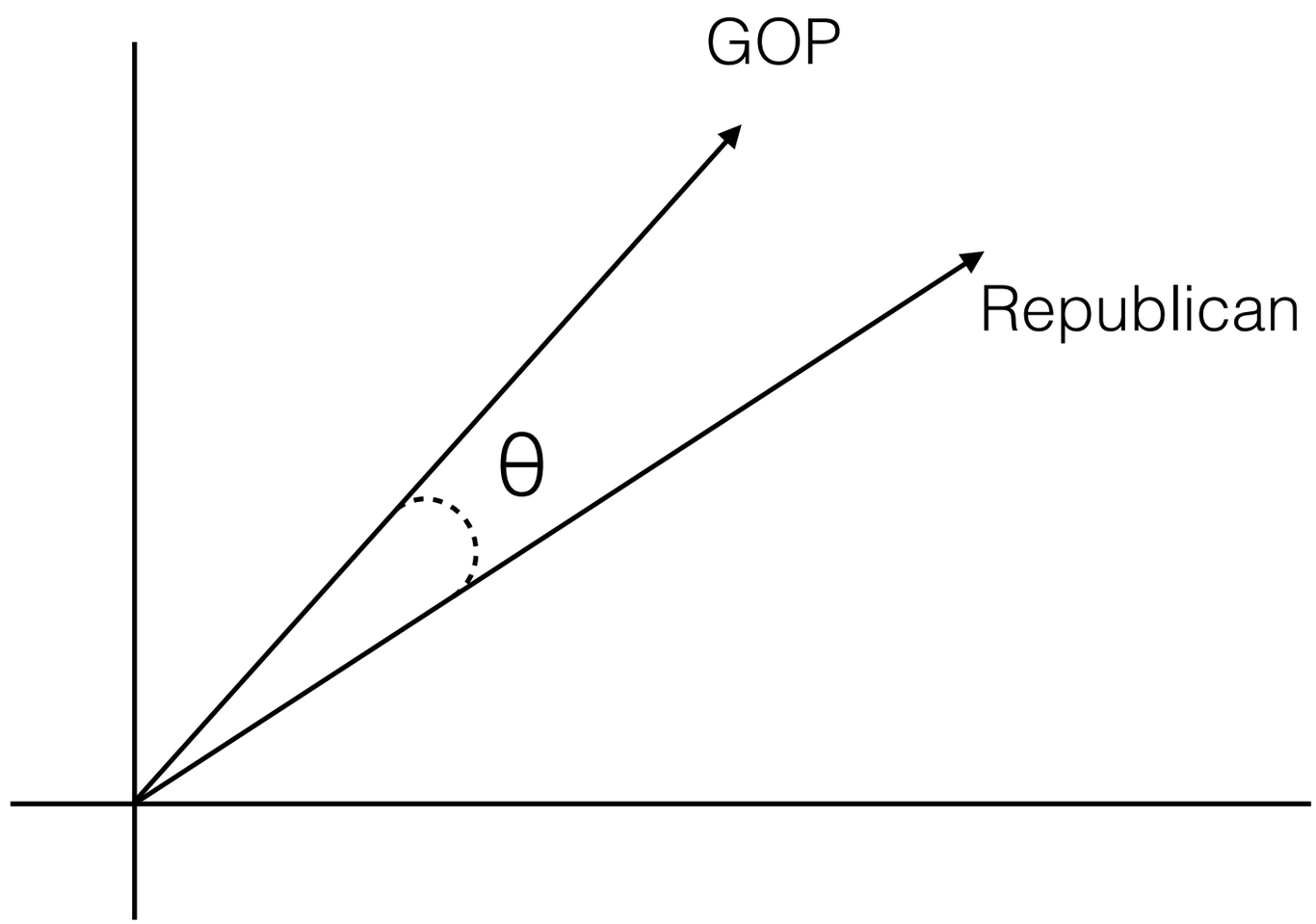
University of Michigan

https://en.wikipedia.org/wiki/Jaccard_index

String Similarity: Cosine Similarity

	Senator	Washington	announced	party	primary	chairman
GOP	1002	41	502	700	400	3
Republican	800	35	521	698	423	10

String Similarity: Cosine Similarity



Clicker Question!

Brown
Brown Uni.

Which metric would (likely) consider the above words more similar?

(a) Jaccard
(b) Cosine

Clicker Question!

Brown
Brown Uni.

Which metric would (likely) consider the above words more similar?

(a) Jaccard
(b) Cosine

Clicker Question!

Motown
Detroit

Which metric would (likely) consider the above words more similar?

(a) Jaccard
(b) Cosine

Clicker Question!

Motown
Detroit

Which metric would (likely) consider the above words more similar?

(a) Jaccard
(b) Cosine

String Similarity: Machine Learn It!!!!

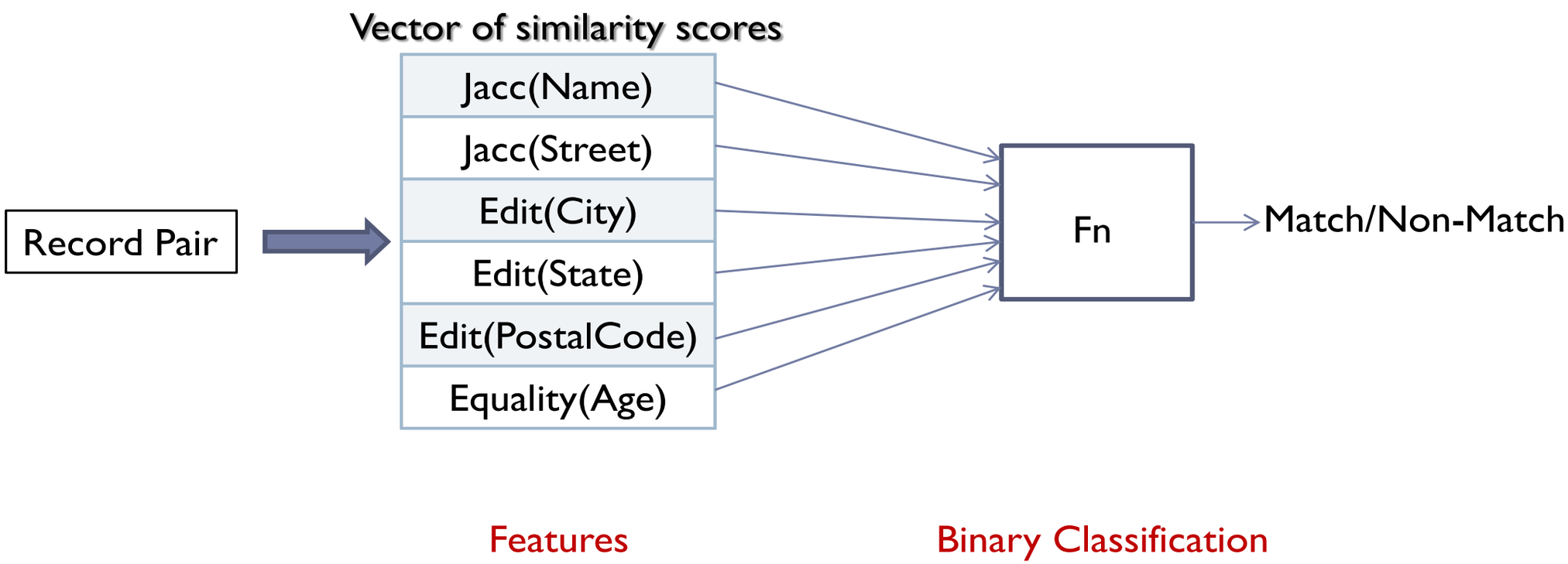
String Similarity: Machine Learn It!!!!

Customer

Id	Name	Street	City	State	P-Code	Age
1	J Smith	123 University Ave	Seattle	Washington	98106	42
2	Mary Jones	245 3rd St	Redmond	WA	98052-1234	30
3	Bob Wilson	345 Broadway	Seattle	Washington	98101	19
4	M Jones	245 Third Street	Redmond	NULL	98052	299
5	Robert Wilson	345 Broadway St	Seattle	WA	98101	19
6	James Smith	123 Univ Ave	Seatle	WA	NULL	41
7	J Widom	123 University Ave	Palo Alto	CA	94305	NULL
…	…	…	…	…	…	…

$WtJaccard =$ 0.57 0.91 1.0 0.0 1.0 1.0

String Similarity: Machine Learn It!!!!



String Similarity: Machine Learn It!!!!

Bob Wilson	345 Broadway	Seattle	Washington	98101	19
Robert Wilson	345 Broadway St	Seattle	WA	98101	19

Match

B Wilson	123 Broadway	Boise	Idaho	83712	19
Robert Wilson	345 Broadway St	Seattle	WA	98101	19

Non-Match

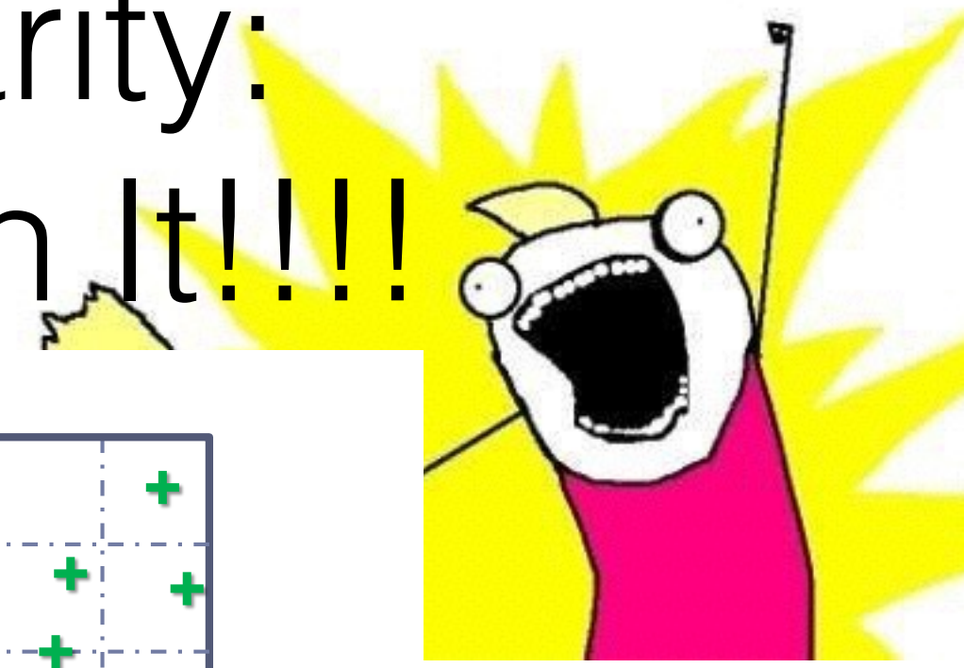
Mary Jones	245 3rd St	Redmond	WA	98052-1234	30
M Jones	245 Third Street	Redmond	NULL	98052	299

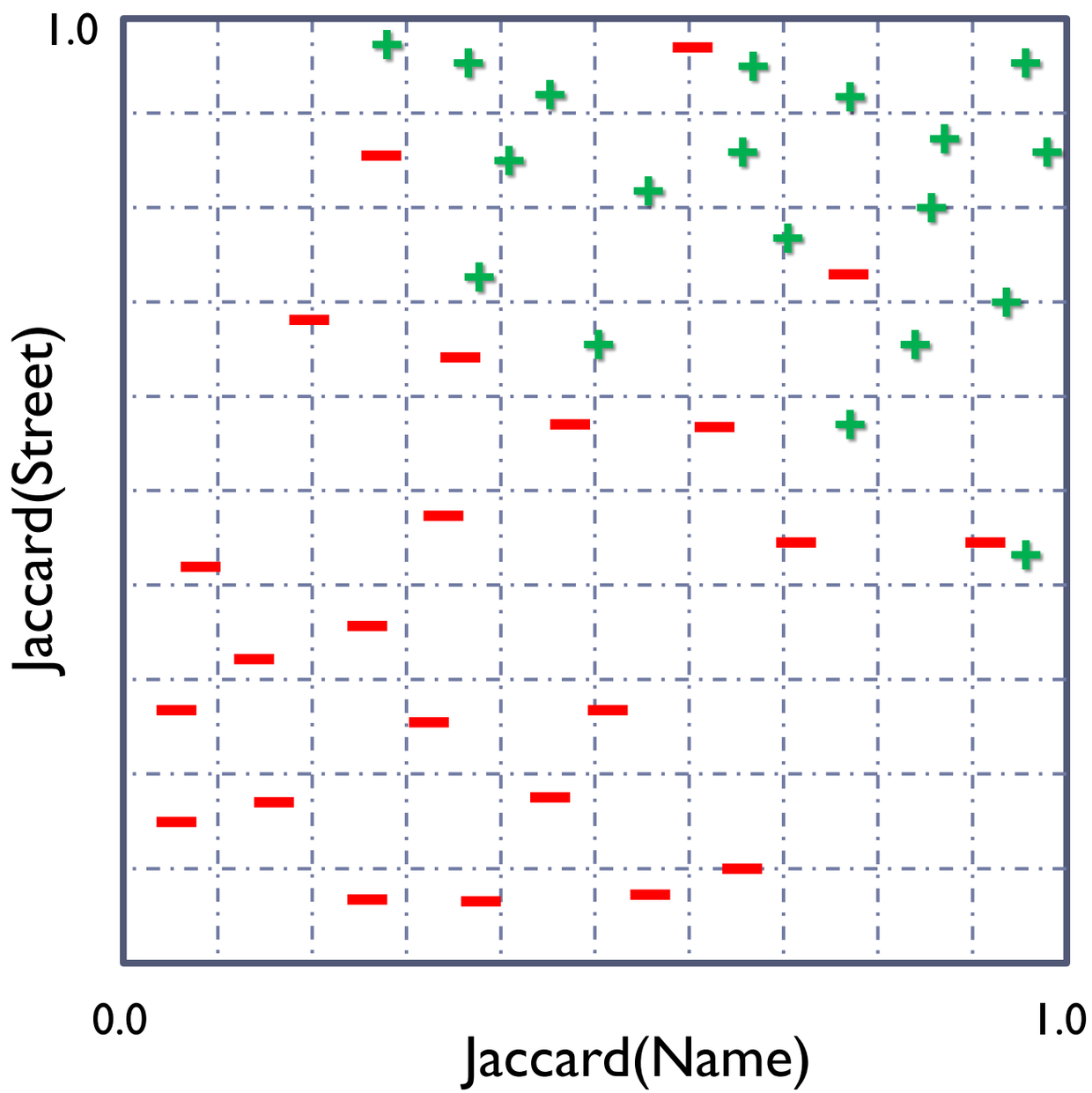
Match

Mary Jones	245 3rd St	Redmond	WA	98052-1234	30
Robert Wilson	345 Broadway St	Seattle	WA	98101	19

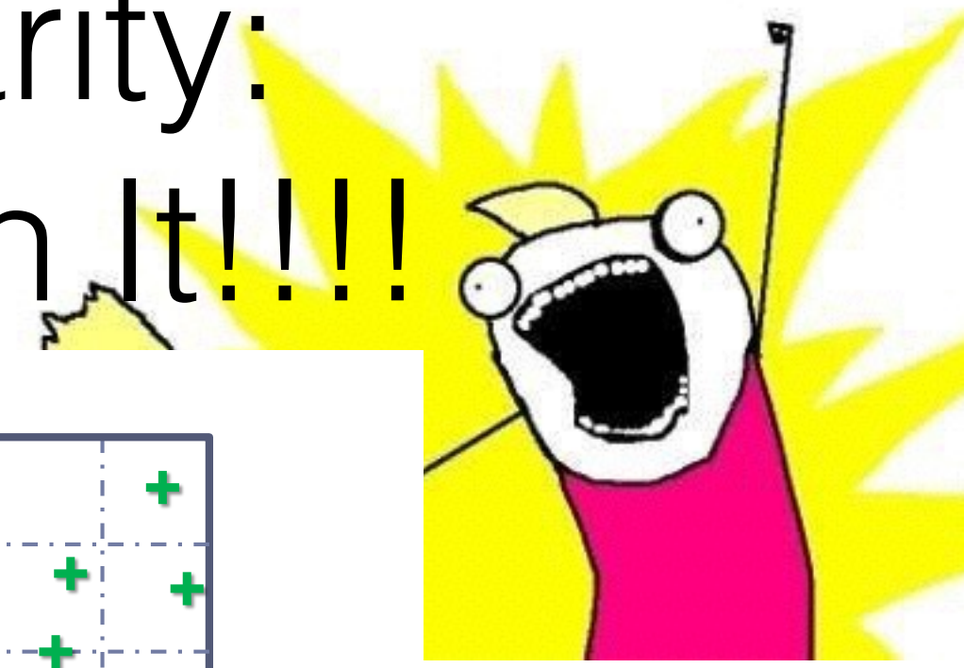
Non-Match

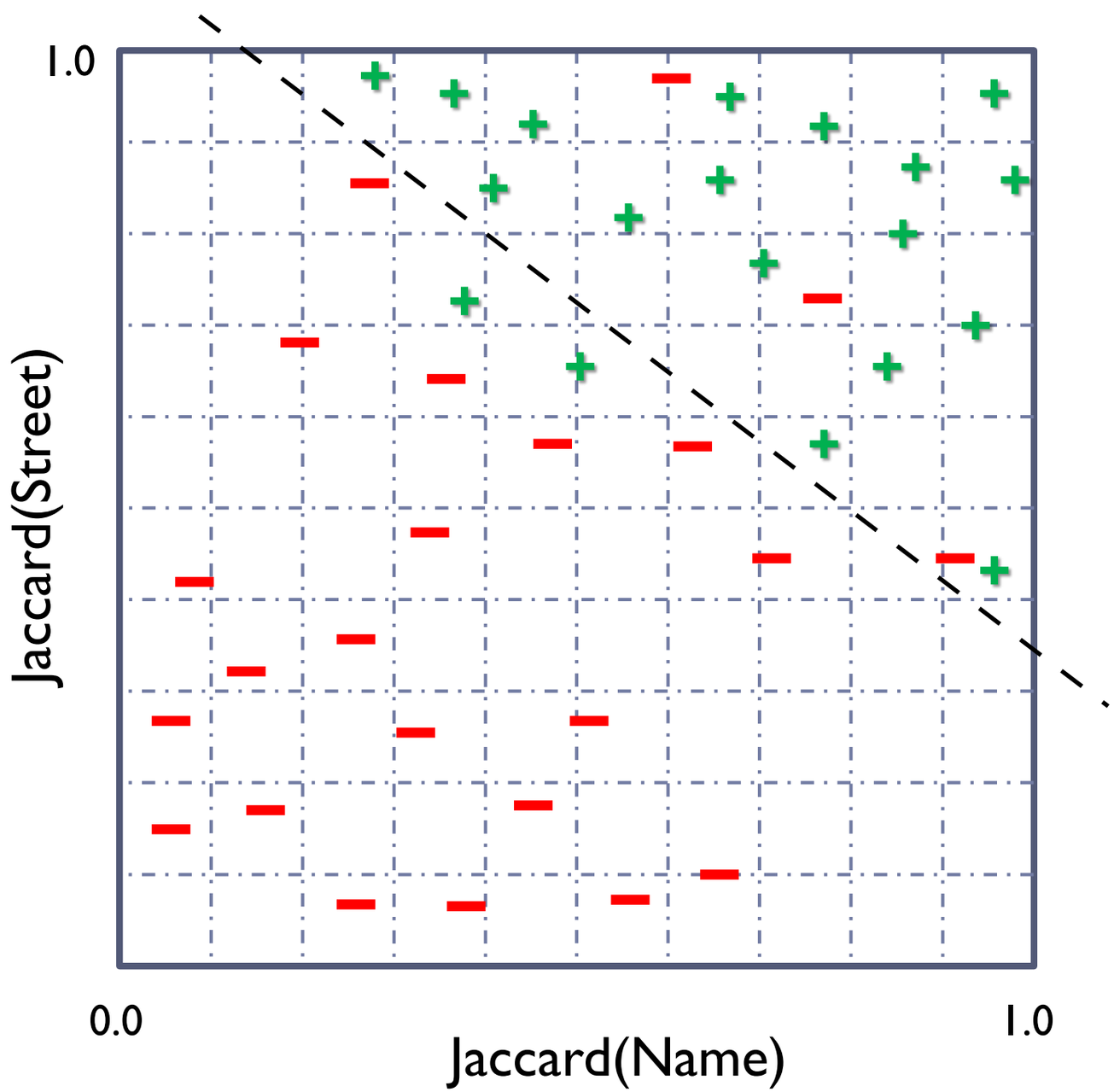
String Similarity: Machine Learn It!!!!





String Similarity: Machine Learn It!!!!





Code-along!

```
cat data.txt | cut -f 2,4 | sort | uniq -c | sort -nr | head
```

Check in

How comfortable would you say you are using the command line?

(a) Not at all…I am actually not even sure what the question means.

(b) I've used it for turnin and a few other things (e.g. copy-pasting to install things), but thats it

(c) I can get around, but its not my "home base"

(d) Command line is my default for developing

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Bash Scripting

https://cs.brown.edu/people/epavlick/articles.txt

1. ID
2. City
3. State
4. Date (YYYY-MM-DD)
5. Time
6. Victim Age
7. Shooter Age
8. Url
9. Title
10. Article Text

cat, less, head, tail

- what does this data even look like?

```
# first 10 lines of file
$ head articles.txt

# first line of file
$ head -n 1 articles.txt

# random 10 lines from file
$ cat articles.txt | shuf | head
```

WC

- how many articles are there

```
# how many bytes, words, and lines are
there?
$ wc articles.txt

# how many lines are there?
$ wc -l articles.txt
```

pipe (|), redirect (>)

```
$ head articles.txt | wc -l
      10

# write output to file called “tmp”
$ head articles.txt > tmp
$ wc -l tmp
      10 tmp

$ head articles.txt | wc -l > tmp
$ cat tmp
      10
```

cut

```
$ cat articles.txt | cut -f 1 | head -n
3
Antioch
Greeley
Bridgeport

$ cat articles.txt | cut -f 3 | cut -f 1
-d '-' | head -n 3
2016
2015
2014
```

sort, uniq

```
# print the lowest 3 values (includes duplicates)
$ cat articles.txt | cut -f 4 | cut -f 1 -d '-'| sort | head -n 3
1929
1932
1932

# print lowest three values (remove duplicates but count how many
occurrances of each
$ cat articles.txt | cut -f 4 | cut -f 1 -d '-'| sort | uniq -c |
head -n 3
   1 1929
   2 1932
   3 1942

# find the most frequent years
$ cat articles.txt | cut -f 4 | cut -f 1 -d '-'| sort | uniq -c |
sort -r | head
5091 2015
1821 2016
1784 NA
```

sort, uniq

How many duplicated entries are there (using url as the uniq id)?

```
# total number of urls (lines)
$ cat articles.txt | cut -f 8 | wc -l
    9584

# number of unique urls
$ cat articles.txt | cut -f 8 | sort | uniq | wc -l
    7990

# number of duplicated urls
$ cat articles.txt | cut -f 8 | sort | uniq -d | wc -l
    981
```

regex (grep, sed, awk)

```
$ cat articles.txt | cut -f 2 | grep "NY" | head -n 5
NY
HOMINY
NYC
NY
NY

$ cat articles.txt | cut -f 2 | grep "^NY$" | head
NY
NY
NY
NY

$ cat articles.txt | cut -f 2 | grep "^NY[.]*" | head
NY
NYC
NY
NY
NY
```

regex (grep, sed, awk)

```
$ cat articles.txt | cut -f 4 | sed "s/
[0-9]/#/g" | head -n 3
####-##-##
####-##-##
####-##-##

$ cat articles.txt | cut -f 3 | sed "s/
[A-Z][A-Z] - //g" | grep -v Unclear |
head -n 3
Minnesota
North Carolina
Michigan
```

Being all fancy…

```
# replace all non-numeric characters with blanks
$ cat articles.txt | cut -f 6 | sed "s/[^0-9]//g" |
head

# plot a histogram of all ages
cat articles.txt | cut -f 6 | sed "s/[^0-9]//g" |
grep -v "^$" | python2 -c "import sys,
matplotlib.pyplot as plt; plt.hist([int(i) for i in
sys.stdin]); plt.show()”

# plot a histogram of all ages, removing outliers
cat articles.txt | cut -f 6 | sed "s/[^0-9]//g" |
grep -v "^$" | python2 -c "import sys,
matplotlib.pyplot as plt; plt.hist([min(int(i), 100)
for i in sys.stdin]); plt.show()"
```

$

This is funny because it is a regex joke. Please laugh and validate me. I will wait.