

# Comparing strings

DATA CLEANING IN PYTHON



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# In this chapter

## Chapter 4 - Record linkage

# Minimum edit distance

|   |   |   |   |   |   |   |   |   |
|---|---|---|---|---|---|---|---|---|
| I | N | T | E | N | T | I | O | N |
|---|---|---|---|---|---|---|---|---|

|   |   |   |   |   |   |   |   |   |
|---|---|---|---|---|---|---|---|---|
| E | X | E | C | U | T | I | O | N |
|---|---|---|---|---|---|---|---|---|

Least possible amount of steps needed to transition from one string to another

# Minimum edit distance

|   |   |   |   |   |   |   |   |   |
|---|---|---|---|---|---|---|---|---|
| I | N | T | E | N | T | I | O | N |
|---|---|---|---|---|---|---|---|---|

|   |   |   |   |   |   |   |   |   |
|---|---|---|---|---|---|---|---|---|
| E | X | E | C | U | T | I | O | N |
|---|---|---|---|---|---|---|---|---|

+ Insertion

- Deletion

↔ Substitution

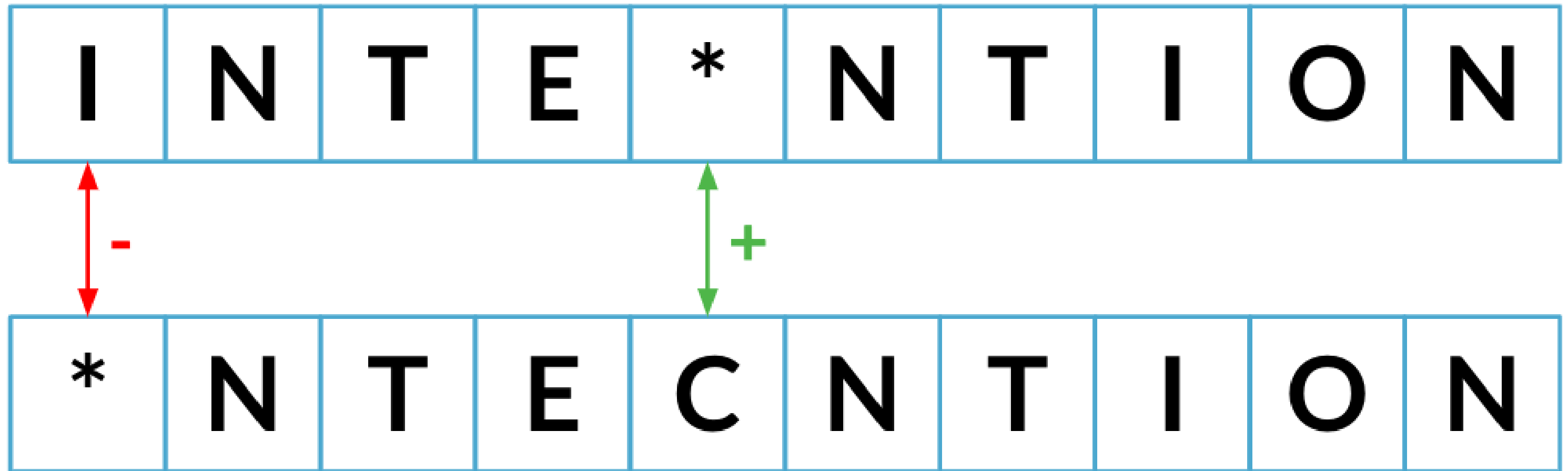
↔ Transposition

Least possible amount of steps needed to transition from one string to another

# Minimum edit distance

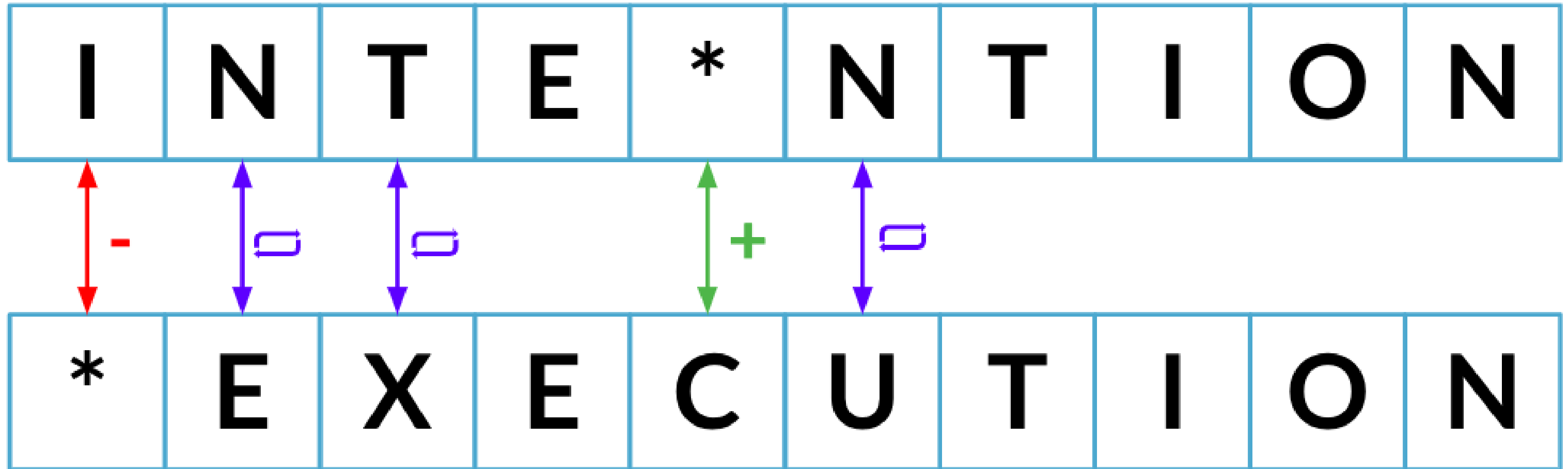
|   |   |   |   |   |   |   |   |   |
|---|---|---|---|---|---|---|---|---|
| I | N | T | E | N | T | I | O | N |
|---|---|---|---|---|---|---|---|---|

# Minimum edit distance



Minimum edit distance so far: 2

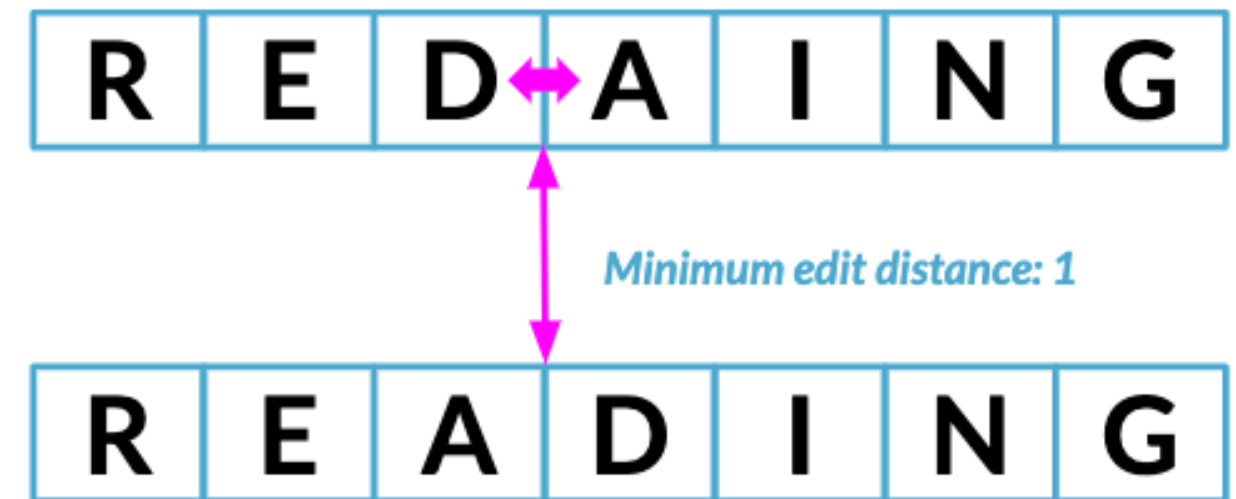
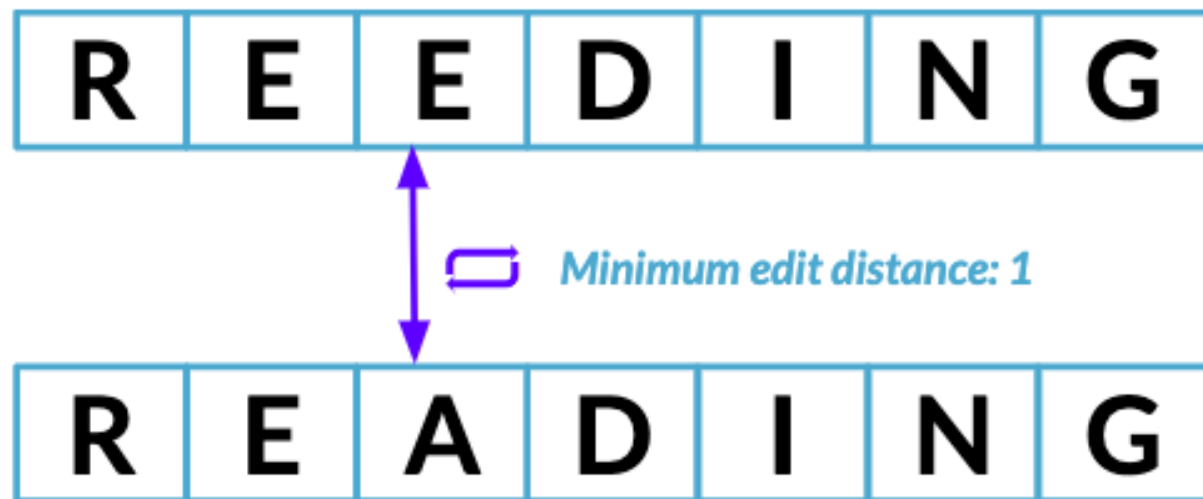
# Minimum edit distance



Minimum edit distance: 5

# Minimum edit distance

Typos for the word: READING





# Minimum edit distance algorithms

| Algorithm           | Operations                                       |
|---------------------|--|
| Damerau-Levenshtein | insertion, substitution, deletion, transposition |
| Levenshtein         | insertion, substitution, deletion                |
| Hamming             | substitution only                                |
| Jaro distance       | transposition only                               |
| ...                 | ...  |

Possible packages: `nltk` , `fuzzywuzzy` , `textdistance` ..

# Minimum edit distance algorithms

| Algorithm           | Operations                                       |
|---------------------|--|
| Damerau-Levenshtein | insertion, substitution, deletion, transposition |
| <i>Levenshtein</i>  | <i>insertion, substitution, deletion</i>         |
| Hamming             | substitution only                                |
| Jaro distance       | transposition only                               |
| ...                 | ...  |

Possible packages: `fuzzywuzzy`

# Simple string comparison

```
# Lets us compare between two strings
from fuzzywuzzy import fuzz

# Compare reeding vs reading
fuzz.WRatio('Reeding', 'Reading')
```

86

# Partial strings and different orderings

```
# Partial string comparison  
fuzz.WRatio('Houston Rockets', 'Rockets')
```

90

```
# Partial string comparison with different order  
fuzz.WRatio('Houston Rockets vs Los Angeles Lakers', 'Lakers vs Rockets')
```

86

# Comparison with arrays

```
# Import process
from fuzzywuzzy import process

# Define string and array of possible matches
string = "Houston Rockets vs Los Angeles Lakers"
choices = pd.Series(['Rockets vs Lakers', 'Lakers vs Rockets',
                    'Houson vs Los Angeles', 'Heat vs Bulls'])

process.extract(string, choices, limit = 2)
```

```
[('Rockets vs Lakers', 86, 0), ('Lakers vs Rockets', 86, 1)]
```

# Collapsing categories with string similarity

## Chapter 2

Use `.replace()` to collapse `"eur"` into `"Europe"`

*What if there are too many variations?*

`"EU"` , `"eur"` , `"Europ"` , `"Europa"` , `"Erope"` , `"Evropa"` ...

String similarity!

# Collapsing categories with string matching

```
print(survey)
```

```
id      state  move_scores
0    California      1
1         Cali      1
2   Caleifornia      1
3   Calefornie      3
4   Calefornie      0
5    California      2
6   Calefernia      0
7     New York      2
8 New York City      2
...
```

```
categories
```

```
state
0 California
1 New York
```

# Collapsing all of the state

```
# For each correct category
for state in categories['state']:

    # Find potential matches in states with typos
    matches = process.extract(state, survey['state'], limit = survey.shape[0])

    # For each potential match match
    for potential_match in matches:

        # If high similarity score
        if potential_match[1] >= 80:

            # Replace typo with correct category
            survey.loc[survey['state'] == potential_match[0], 'state'] = state
```



# Record linkage

| Event                              | Time  |
|------------------------------------|-------|
| Houston Rockets vs Chicago Bulls   | 19:00 |
| Miami Heat vs Los Angeles Lakers   | 19:00 |
| Brooklyn Nets vs Orlando Magic     | 20:00 |
| Denver Nuggets vs Miami Heat       | 21:00 |
| San Antonio Spurs vs Atlanta Hawks | 21:00 |



| Event                  | Time  |   |
|------------------------|-------|---|
| NBA: Nets vs Magic     | 8 pm  |   |
| NBA: Bulls vs Rockets  | 9 pm  |   |
| NBA: Heat vs Lakers    | 7 pm  |   |
| NBA: Grizzlies vs Heat | 10 pm | ✓ |
| NBA: Heat vs Cavaliers | 9 pm  | ✓ |

# Let's practice!

DATA CLEANING IN PYTHON

# Generating pairs

DATA CLEANING IN PYTHON



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# Motivation

| Event                              | Time  |
|------------------------------------|-------|
| Houston Rockets vs Chicago Bulls   | 19:00 |
| Miami Heat vs Los Angeles Lakers   | 19:00 |
| Brooklyn Nets vs Orlando Magic     | 20:00 |
| Denver Nuggets vs Miami Heat       | 21:00 |
| San Antonio Spurs vs Atlanta Hawks | 21:00 |

| Event                  | Time  |
|------------------------|-------|
| NBA: Nets vs Magic     | 8 pm  |
| NBA: Bulls vs Rockets  | 9 pm  |
| NBA: Heat vs Lakers    | 7 pm  |
| NBA: Grizzlies vs Heat | 10 pm |
| NBA: Heat vs Cavaliers | 9 pm  |

# When joins won't work

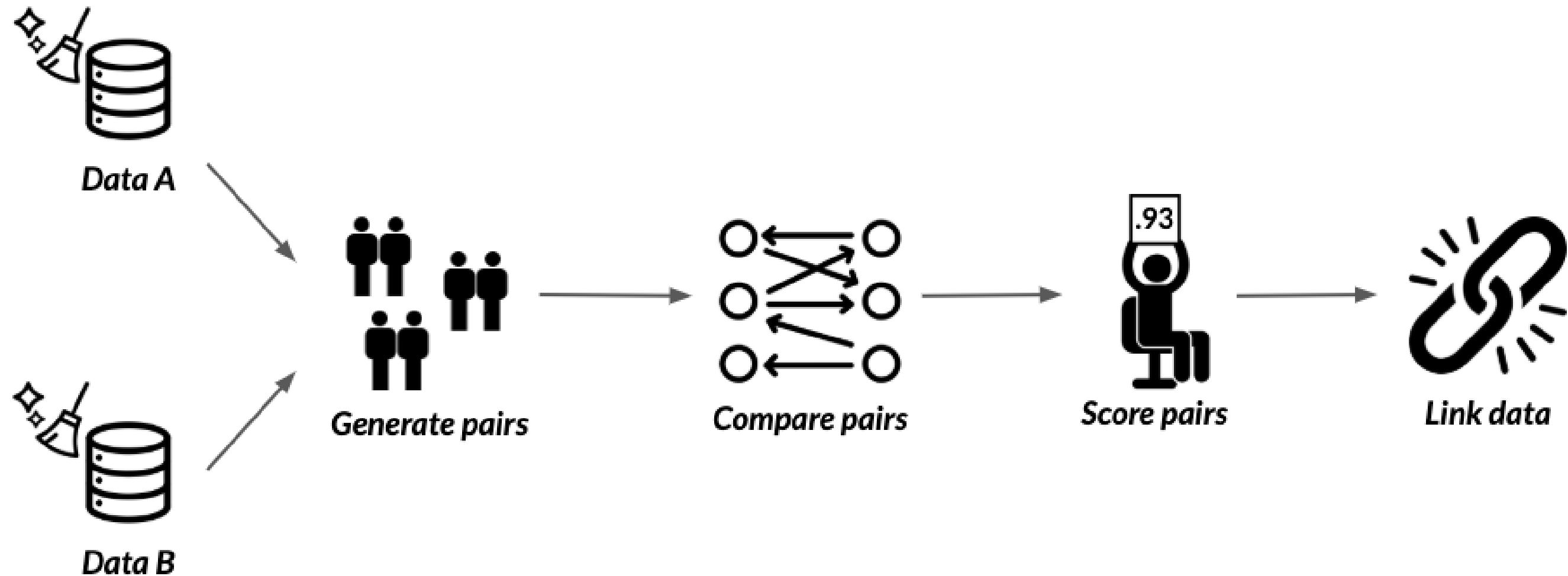
| Event                              | Time  |
|------------------------------------|-------|
| Houston Rockets vs Chicago Bulls   | 19:00 |
| Miami Heat vs Los Angeles Lakers   | 19:00 |
| Brooklyn Nets vs Orlando Magic     | 20:00 |
| Denver Nuggets vs Miami Heat       | 21:00 |
| San Antonio Spurs vs Atlanta Hawks | 21:00 |



| Event                  | Time  |
|------------------------|-------|
| NBA: Nets vs Magic     | 8 pm  |
| NBA: Bulls vs Rockets  | 9 pm  |
| NBA: Heat vs Lakers    | 7 pm  |
| NBA: Grizzlies vs Heat | 10 pm |
| NBA: Heat vs Cavaliers | 9 pm  |



# Record linkage



The `recordlinkage` package

# Our DataFrames

census\_A

```
      given_name  surname date_of_birth      suburb state address_1
rec_id
rec-1070-org    michaela  neumann    19151111  winston hills    cal  stanley street
rec-1016-org    courtney  painter    19161214    richlands    txs  pinkerton circuit
...
```

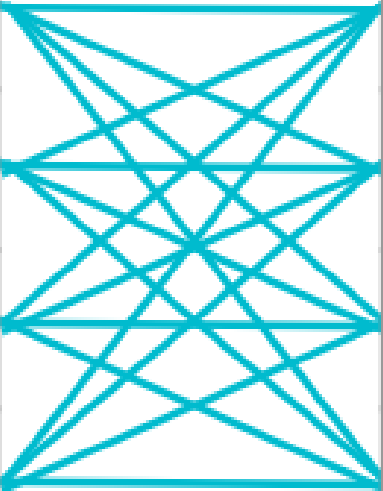
census\_B

```
      given_name  surname date_of_birth      suburb state address_1
rec_id
rec-561-dup-0      elton      NaN    19651013  windermere    ny  light setreet
rec-2642-dup-0  mitchell    maxon    19390212  north ryde    cal  edkins street
...
```

# Generating pairs

census\_A

| rec_id | given_name | ... | state |
|--------|------------|-----|-------|
| ...    | ...        | ... | ...   |
| ...    | ...        | ... | ...   |
| ...    | ...        | ... | ...   |
| ...    | ...        | ... | ...   |

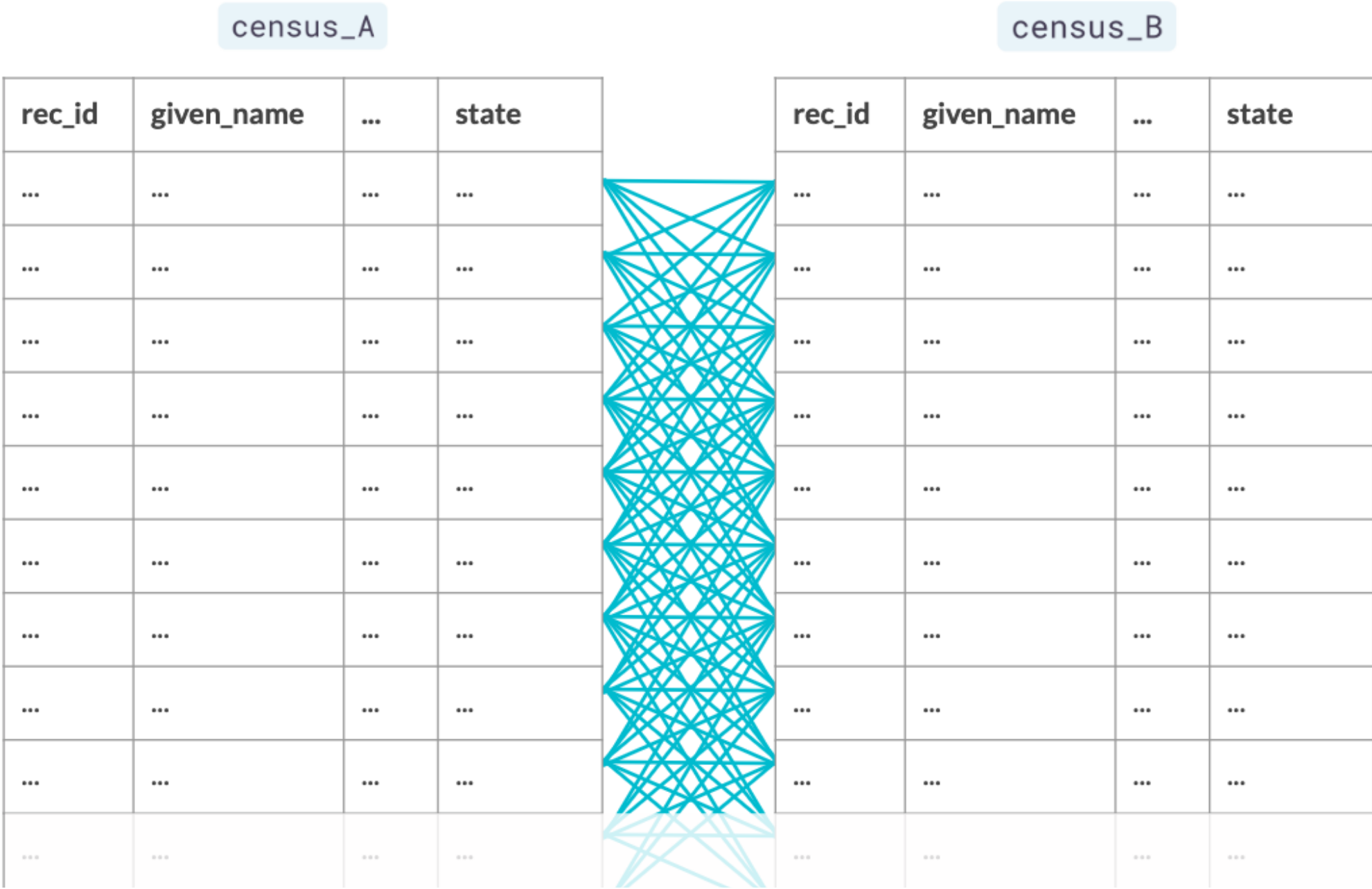


census\_B

| rec_id | given_name | ... | state |
|--------|------------|-----|-------|
| ...    | ...        | ... | ...   |
| ...    | ...        | ... | ...   |
| ...    | ...        | ... | ...   |
| ...    | ...        | ... | ...   |



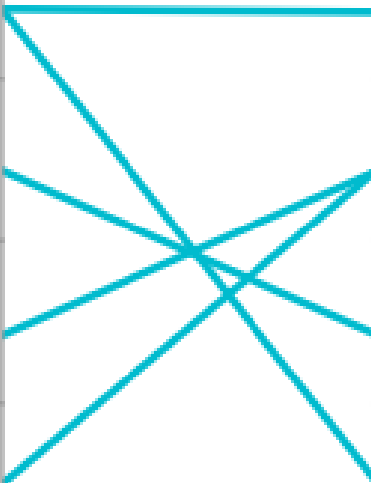
# Generating pairs



# Blocking

census\_A

| rec_id | given_name | ... | state |
|--------|------------|-----|-------|
| ...    | ...        | ... | cal   |
| ...    | ...        | ... | ny    |
| ...    | ...        | ... | txs   |
| ...    | ...        | ... | txs   |



census\_A

| rec_id | given_name | ... | state |
|--------|------------|-----|-------|
| ...    | ...        | ... | cal   |
| ...    | ...        | ... | txs   |
| ...    | ...        | ... | ny    |
| ...    | ...        | ... | cal   |

# Generating pairs

```
# Import recordlinkage
import recordlinkage

# Create indexing object
indexer = recordlinkage.Index()

# Generate pairs blocked on state
indexer.block('state')
pairs = indexer.index(census_A, census_B)
```

# Generating pairs

```
print(pairs)
```

```
MultiIndex(levels=[['rec-1007-org', 'rec-1016-org', 'rec-1054-org', 'rec-1066-org',  
'rec-1070-org', 'rec-1075-org', 'rec-1080-org', 'rec-110-org', 'rec-1146-org',  
'rec-1157-org', 'rec-1165-org', 'rec-1185-org', 'rec-1234-org', 'rec-1271-org',  
'rec-1280-org', .....],  
            [66, 14, 13, 18, 34, 39, 0, 16, 80, 50, 20, 69, 28, 25, 49, 77, 51, 85, 52, 63, 74, 61,  
83, 91, 22, 26, 55, 84, 11, 81, 97, 56, 27, 48, 2, 64, 5, 17, 29, 60, 72, 47, 92, 12,  
95, 15, 19, 57, 37, 70, 94]], names=['rec_id_1', 'rec_id_2'])
```

# Comparing the DataFrames

```
# Generate the pairs
pairs = indexer.index(census_A, census_B)

# Create a Compare object
compare_cl = recordlinkage.Compare()

# Find exact matches for pairs of date_of_birth and state
compare_cl.exact('date_of_birth', 'date_of_birth', label='date_of_birth')
compare_cl.exact('state', 'state', label='state')

# Find similar matches for pairs of surname and address_1 using string similarity
compare_cl.string('surname', 'surname', threshold=0.85, label='surname')
compare_cl.string('address_1', 'address_1', threshold=0.85, label='address_1')

# Find matches
potential_matches = compare_cl.compute(pairs, census_A, census_B)
```

# Finding matching pairs

```
print(potential_matches)
```

| rec_id_1     | rec_id_2       | date_of_birth | state | surname | address_1 |
|--------------|----------------|---------------|-------|---------|-----------|
| rec-1070-org | rec-561-dup-0  | 0             | 1     | 0.0     | 0.0       |
|              | rec-2642-dup-0 | 0             | 1     | 0.0     | 0.0       |
|              | rec-608-dup-0  | 0             | 1     | 0.0     | 0.0       |
| ...          |                |               |       |         |           |
| rec-1631-org | rec-4070-dup-0 | 0             | 1     | 0.0     | 0.0       |
|              | rec-4862-dup-0 | 0             | 1     | 0.0     | 0.0       |
|              | rec-629-dup-0  | 0             | 1     | 0.0     | 0.0       |
| ...          |                |               |       |         |           |

# Finding the only pairs we want

```
potential_matches[potential_matches.sum(axis = 1) == 2]
```

| rec_id_1     | rec_id_2       | date_of_birth | state | surname | address_1 |
|--------------|----------------|---------------|-------|---------|-----------|
| rec-4878-org | rec-4878-dup-0 | 1             | 1     | 1.0     | 0.0       |
| rec-417-org  | rec-2867-dup-0 | 0             | 1     | 0.0     | 1.0       |
| rec-3964-org | rec-394-dup-0  | 0             | 1     | 1.0     | 0.0       |
| rec-1373-org | rec-4051-dup-0 | 0             | 1     | 1.0     | 0.0       |
|              | rec-802-dup-0  | 0             | 1     | 1.0     | 0.0       |
| rec-3540-org | rec-470-dup-0  | 0             | 1     | 1.0     | 0.0       |

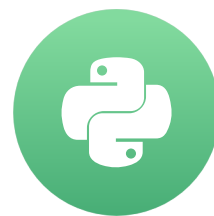
# Let's practice!

DATA CLEANING IN PYTHON



# Linking DataFrames

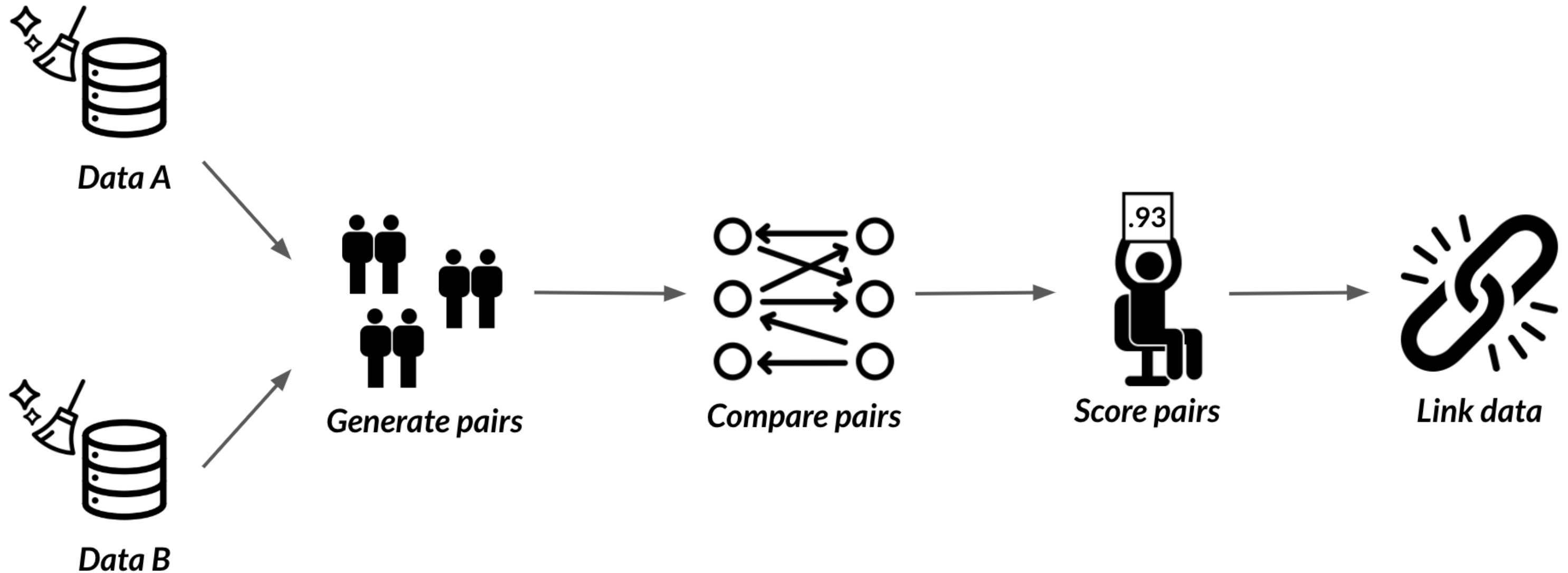
DATA CLEANING IN PYTHON



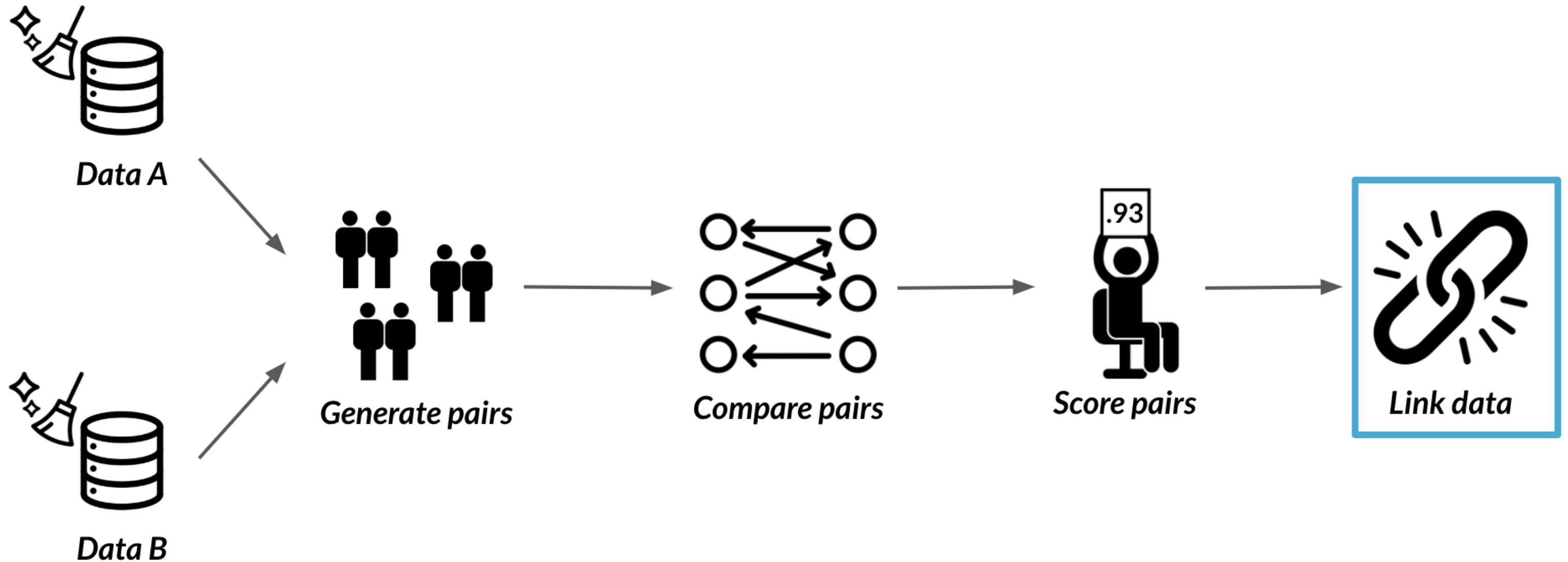
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# Record linkage



# Record linkage



# Our DataFrames

census\_A

```
      given_name  surname date_of_birth      suburb state address_1
rec_id
rec-1070-org    michaela  neumann    19151111  winston hills    nsw  stanley street
rec-1016-org    courtney  painter    19161214    richlands    vic  pinkerton circuit
...
```

census\_B

```
      given_name  surname date_of_birth      suburb state address_1
rec_id
rec-561-dup-0      elton      NaN    19651013  windermere    vic  light setreet
rec-2642-dup-0  mitchell    maxon    19390212  north ryde    nsw  edkins street
...
```

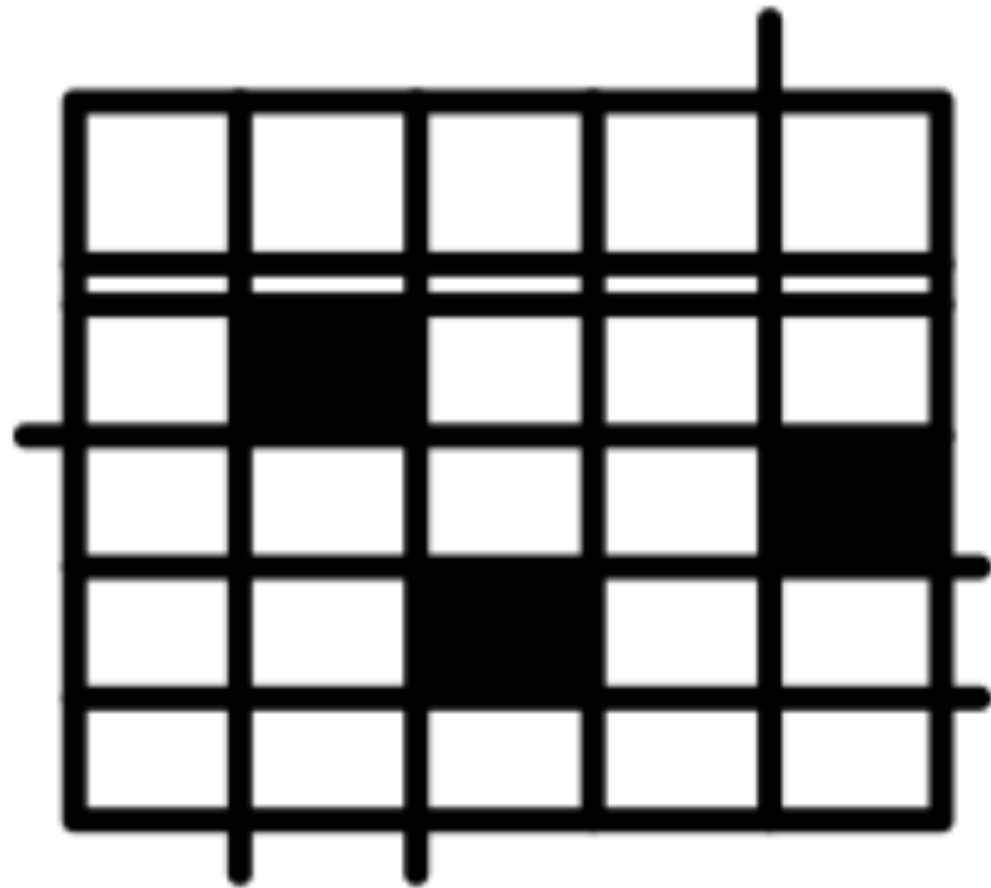
# What we've already done

```
# Import recordlinkage and generate full pairs
import recordlinkage
indexer = recordlinkage.Index()
indexer.block('state')
full_pairs = indexer.index(census_A, census_B)

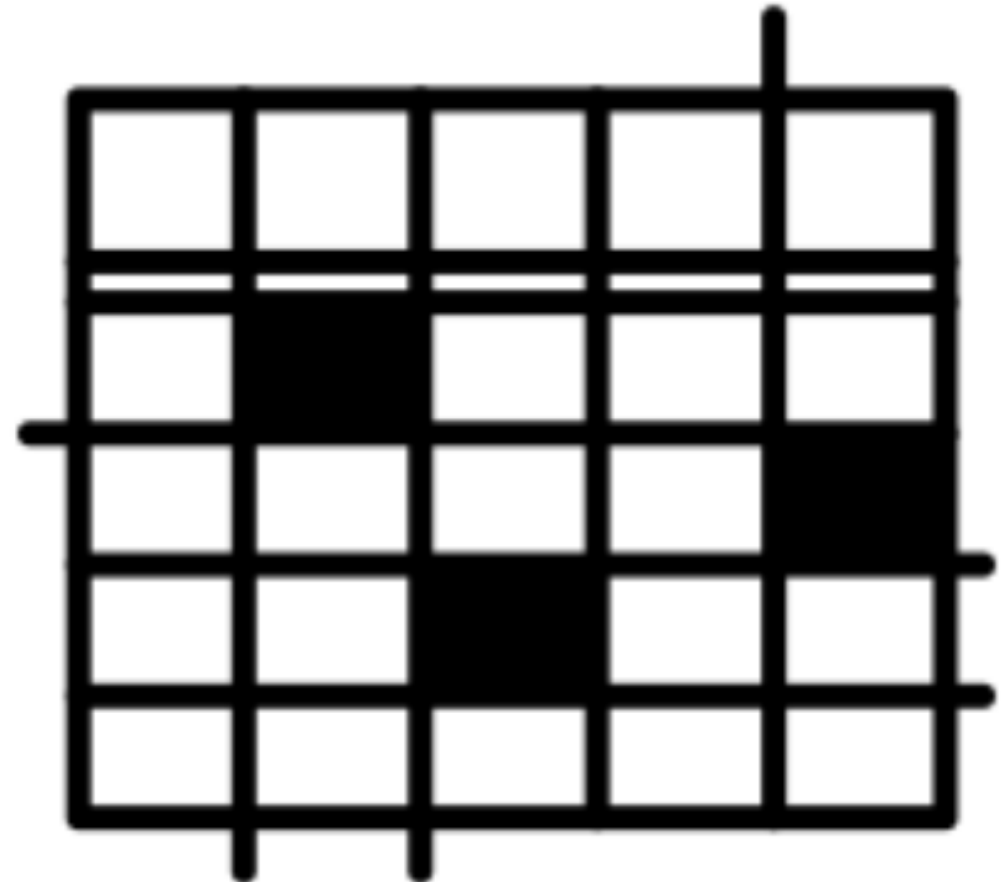
# Comparison step
compare_cl = recordlinkage.Compare()
compare_cl.exact('date_of_birth', 'date_of_birth', label='date_of_birth')
compare_cl.exact('state', 'state', label='state')
compare_cl.string('surname', 'surname', threshold=0.85, label='surname')
compare_cl.string('address_1', 'address_1', threshold=0.85, label='address_1')

potential_matches = compare_cl.compute(full_pairs, census_A, census_B)
```

# What we're doing now



census\_A



census\_B

# Our potential matches

```
potential_matches
```

|              |                | date_of_birth | state | surname | address_1 |
|--------------|----------------|---------------|-------|---------|-----------|
| rec_id_1     | rec_id_2       |               |       |         |           |
| rec-1070-org | rec-561-dup-0  | 0             | 1     | 0.0     | 0.0       |
|              | rec-2642-dup-0 | 0             | 1     | 0.0     | 0.0       |
|              | rec-608-dup-0  | 0             | 1     | 0.0     | 0.0       |
| ...          |                | ...           | ...   | ...     | ...       |
| rec-1631-org | rec-1697-dup-0 | 0             | 1     | 0.0     | 0.0       |
|              | rec-4404-dup-0 | 0             | 1     | 0.0     | 0.0       |
|              | rec-3780-dup-0 | 0             | 1     | 0.0     | 0.0       |
| ...          |                | ...           | ...   | ...     | ...       |

# Our potential matches

```
potential_matches
```

```
census_A           date_of_birth  state  surname  address_1
rec_id_1  rec_id_2
rec-1070-org rec-561-dup-0      0      1      0.0      0.0
           rec-2642-dup-0      0      1      0.0      0.0
           rec-608-dup-0      0      1      0.0      0.0
...
rec-1631-org rec-1697-dup-0      0      1      0.0      0.0
           rec-4404-dup-0      0      1      0.0      0.0
           rec-3780-dup-0      0      1      0.0      0.0
...
...      ...      ...      ...      ...
```



# Our potential matches

```
potential_matches
```

| <b>census_A</b> | <b>census_B</b> | date_of_birth | state | surname | address_1 |
|-----------------|-----------------|---------------|-------|---------|-----------|
| rec_id_1        | rec_id_2        |               |       |         |           |
| rec-1070-org    | rec-561-dup-0   | 0             | 1     | 0.0     | 0.0       |
|                 | rec-2642-dup-0  | 0             | 1     | 0.0     | 0.0       |
|                 | rec-608-dup-0   | 0             | 1     | 0.0     | 0.0       |
| ...             |                 | ...           | ...   | ...     | ...       |
| rec-1631-org    | rec-1697-dup-0  | 0             | 1     | 0.0     | 0.0       |
|                 | rec-4404-dup-0  | 0             | 1     | 0.0     | 0.0       |
|                 | rec-3780-dup-0  | 0             | 1     | 0.0     | 0.0       |
| ...             |                 | ...           | ...   | ...     | ...       |

# Our potential matches

potential\_matches

| census_A     | census_B       | date_of_birth | state    | surname    | address_1  |
|--------------|----------------|---------------|----------|------------|------------|
| rec_id_1     | rec_id_2       |               |          |            |            |
| rec-1070-org | rec-561-dup-0  | 0             | 1        | 0.0        | 0.0        |
|              | rec-2642-dup-0 | <u>0</u>      | <u>1</u> | <u>0.0</u> | <u>0.0</u> |
|              | rec-608-dup-0  | 0             | 1        | 0.0        | 0.0        |
| ...          |                | ...           | ...      | ...        | ...        |
| rec-1631-org | rec-1697-dup-0 | 0             | 1        | 0.0        | 0.0        |
|              | rec-4404-dup-0 | 0             | 1        | 0.0        | 0.0        |
|              | rec-3780-dup-0 | 0             | 1        | 0.0        | 0.0        |
| ...          |                | ...           | ...      | ...        | ...        |

# Probable matches

```
matches = potential_matches[potential_matches.sum(axis = 1) >= 3]
print(matches)
```

|              |                | date_of_birth | state | surname | address_1 |
|--------------|----------------|---------------|-------|---------|-----------|
| rec_id_1     | rec_id_2       |               |       |         |           |
| rec-2404-org | rec-2404-dup-0 | 1             | 1     | 1.0     | 1.0       |
| rec-4178-org | rec-4178-dup-0 | 1             | 1     | 1.0     | 1.0       |
| rec-1054-org | rec-1054-dup-0 | 1             | 1     | 1.0     | 1.0       |
| ...          | ...            | ...           | ...   | ...     | ...       |
| rec-1234-org | rec-1234-dup-0 | 1             | 1     | 1.0     | 1.0       |
| rec-1271-org | rec-1271-dup-0 | 1             | 1     | 1.0     | 1.0       |

# Probable matches

```
matches = potential_matches[potential_matches.sum(axis = 1) >= 3]
print(matches)
```

|              | <b>census_B</b> | date_of_birth | state | surname | address_1 |
|--------------|-----------------|---------------|-------|---------|-----------|
| rec_id_1     | rec_id_2        |               |       |         |           |
| rec-2404-org | rec-2404-dup-0  | 1             | 1     | 1.0     | 1.0       |
| rec-4178-org | rec-4178-dup-0  | 1             | 1     | 1.0     | 1.0       |
| rec-1054-org | rec-1054-dup-0  | 1             | 1     | 1.0     | 1.0       |
| ...          | ...             | ...           | ...   | ...     | ...       |
| rec-1234-org | rec-1234-dup-0  | 1             | 1     | 1.0     | 1.0       |
| rec-1271-org | rec-1271-dup-0  | 1             | 1     | 1.0     | 1.0       |

# Get the indices

```
matches.index
```

```
MultiIndex(levels=[['rec-1007-org', 'rec-1016-org', 'rec-1054-org', 'rec-1066-org',  
'rec-1070-org', 'rec-1075-org', 'rec-1080-org', 'rec-110-org', ...
```

```
# Get indices from census_B only  
duplicate_rows = matches.index.get_level_values(1)  
print(census_B_index)
```

```
Index(['rec-2404-dup-0', 'rec-4178-dup-0', 'rec-1054-dup-0', 'rec-4663-dup-0',  
      'rec-485-dup-0', 'rec-2950-dup-0', 'rec-1234-dup-0', ... , 'rec-299-dup-0'])
```

# Linking DataFrames

```
# Finding duplicates in census_B
census_B_duplicates = census_B[census_B.index.isin(duplicate_rows)]
```

```
# Finding new rows in census_B
census_B_new = census_B[~census_B.index.isin(duplicate_rows)]
```

```
# Link the DataFrames!
full_census = census_A.append(census_B_new)
```

```
# Import recordlinkage and generate pairs and compare across columns
...
# Generate potential matches
potential_matches = compare_cl.compute(full_pairs, census_A, census_B)

# Isolate matches with matching values for 3 or more columns
matches = potential_matches[potential_matches.sum(axis = 1) >= 3]

# Get index for matching census_B rows only
duplicate_rows = matches.index.get_level_values(1)

# Finding new rows in census_B
census_B_new = census_B[~census_B.index.isin(duplicate_rows)]

# Link the DataFrames!
full_census = census_A.append(census_B_new)
```

# Let's practice!

DATA CLEANING IN PYTHON



# Congratulations!

DATA CLEANING IN PYTHON



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# What we've learned



Diagnose dirty  
data



Side effects of  
dirty data



Clean data

# What we've learned



**Data Type  
Constraints**

*Strings  
Numeric data*

...



**Data Range  
Constraints**

*Out of range data  
Out of range dates*

...



**Uniqueness  
Constraints**

*Finding duplicates  
Treating them*

...

## Chapter 1 - Common data problems

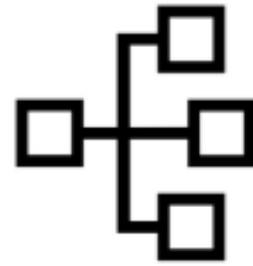
# What we've learned



## **Membership Constraints**

*Finding inconsistent categories  
Treating them with joins*

...



## **Categorical Variables**

*Finding inconsistent categories  
Collapsing them into less*

...



## **Cleaning Text Data**

*Unifying formats  
Finding lengths*

...

## Chapter 2 - Text and categorical data problems

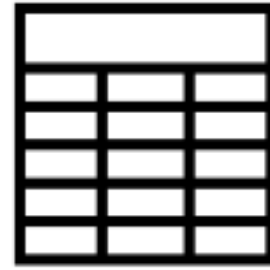
# What we've learned



## **Uniformity**

*Unifying currency formats  
Unifying date formats*

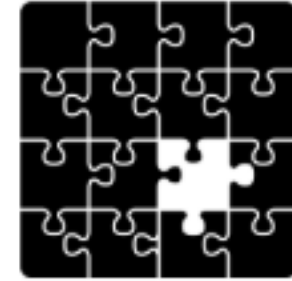
...



## **Cross field validation**

*Summing across rows  
Building assert functions*

...



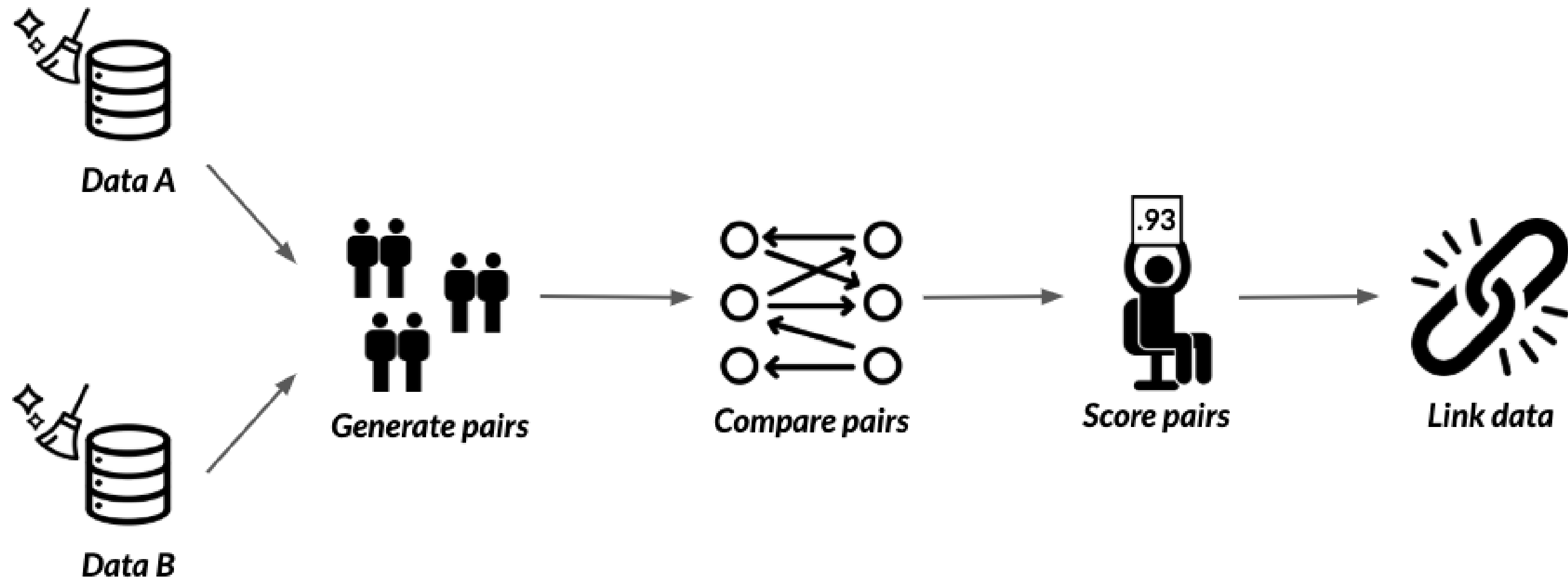
## **Completeness**

*Finding missing data  
Treating them*

...

## Chapter 3 - Advanced data problems

# What we've learned



## Chapter 4 - Record linkage

# More to learn!



*And much more!*

# More to learn!





# More to learn!



# Thank you!

DATA CLEANING IN PYTHON