# Module 3: Pipeline Approaches and Deterministic ER

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# Reading

- ▶ Binette and Steorts (2020)
- ► Christen (2012), give page numbers

# Agenda

- ► Pipeline Approach
- ► Deterministic Record Linkage
- Exact Matching
- Scoring Functions
- ► Application to XX

# Load R packages

```
## Loading required package: DBI
## Loading required package: RSQLite
## Loading required package: ff
## Loading required package: bit
##
## Attaching package: 'bit'
## The following object is masked from 'package:base':
##
##
       xor
## Attaching package ff
## - getOption("fftempdir")=="/var/folders/bv/xhclmwh90zg08
## - getOption("ffextension")=="ff"
## - getOption("ffdrop")==TRUE
```

# Data Cleaning Pipeline

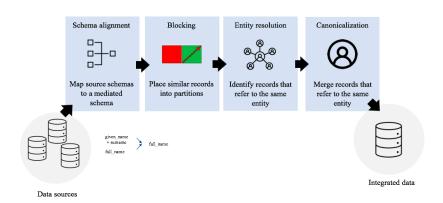


Figure 1: Data cleaning pipeline.

# Deterministic Record Linkage

The most commonly used record linkage methods are based on a series of deterministic rules involving the comparison of record attributes.

# **Exact Matching**

- ► Exact matching is where two record pairs are linked if they agree on all common attributes.
- ► An extension, off by k-matching, states that two record pairs are a match if they match on all common attributes except k, where k is an integer larger than 0.
- ► Exact matching (or extensions) are used when all the attributes are categorical as it tends to perform well, as opposed to when textual variables are introduced.

# Scoring Rules

- Record attributes are often distorted by noise. Why would this occur?
- Linkage rules should account for such noise, distortions, and errors through scoring rules or functions.
- Examples commonly used for westernized names are the Edit (Levenshtein), Jaro, and Jaro-Winkler distance functions.

# Edit (Levenshtein) distance (1966)

The Edit distance calculates the minimum number of substitutions required to transform a string  $s_1$  into a string  $s_2$ .

Formally,

$$\mathsf{Edit} = 1 - \frac{\mathit{L}}{\mathit{maxLength}(s_1, s_2)}.$$

## Example

Consider the number of substitutions required to transform from **Adam** to **Alan**. Use the Edit distance formulate to find the similarity score that is between [0,1].

#### Solution

The number of substitutions required is L = 2.

This is normalized into a similarity function using the following:

Edit = 
$$1 - \frac{L}{maxLength(s_1, s_2)} = 1 - 2/4 = 1 - 0.5 = 0.5$$

## Solution

Let's verify this in R.

```
s1 <- "Adam"
s2 <- "Alan"
levenshteinSim("s1", "s2")</pre>
```

```
## [1] 0.5
```

#### Jaro-Winkler

- ► The Jaro distance (1989), called J, considered common characters and character transpositions.
- ▶ The Jaro-Winkler (1990) similarity measure, denoted JW is:

$$JW(A, B) = J(A, B) + \frac{0.1p}{1}(1 - J(A, B))$$

where p is the # of the first four characters that agree exactly.

## Example

Let's return to the example of comparing Adam and Alan.

- ▶ Here, p = 1.
- ▶ Given the complexity, we will calculate J and JW using R.

## Example

```
## It seems Jaro is not supported in R
jarowinkler(s1,s2)
```

## [1] 0.7

e.g. Adam vs Alan: p=1, J=0.67 and JW=0.7.

These work well on English names that are less than 7 characters.

### Other distance functions

There are many other distance functions, such as the Jaccard, Hamming, and Cosine distances just to name a few.

# Case study on El Salvador.

Let's consider a case study from El Salvador.

## Civil War in the Republic of El Salvador

Between 1980 and 1991, the Republic of El Salvador witnessed a civil war between the central government, the left-wing guerrilla Farabundo Marti National Liberation Front (FMLN), and right-wing paramilitary death squads.

After the peace agreement in 1992, the United Nations created a Commission on the Truth (UNTC) for El Salvador, which invited members of Salvadoran society to report war-related human rights violations, which mainly focused on killings and disappearances.

In order to collect such information the UNTC invited individuals through newspapers, radio, and television advertisements to come forward and testify.

The UNTC opened offices through El Salvador where witnesses could provide their testimonials, and this resulted in a list of potential victims with names, date of death, and reported location.

# Data analysis

#### Let's read in the data and inspect it.

```
# read in data
df <- read.csv("./sv-mauricio/sv-mauricio.csv")
head(df)</pre>
```

```
ID
                     lastname firstname day month year geocode HandID dept muni
     26
         32 ASENSIO ERNANDES
                                 ALBERTO
                                                 2 1981
                                                         150000
                                                                    NA
                                                                          15
                                                                              NA
     84
         95
               PALASIOS AYALA
                                 OBIDIO
                                         NA
                                                10 1985
                                                         150000
                                                                    NA
                                                                          15
                                                                              NA
## 3 100 117
                        PALMA SEBASTIAN
                                         13
                                                 5 1980
                                                         40000
                                                                    NA
                                                                              NA
## 4 143 173
                        PERES
                                ARCADIO
                                                 8 1984
                                                          40000
                                                                    NA
                                                                              NA
## 5 170 205
                 MAYA QUESADA
                                ANTONIO
                                                 9 1984
                                                                    NA
                                                                              NA
## 6 189 227
                        MEJIA
                                ALFONSO
                                         13
                                                 5 1980
                                                          40000
                                                                    NA
                                                                              NA
```

## First steps

What steps do we need to take before running any algorithms or methods on this data?

Meet with your group and discuss. Be prepared to discuss ideas and any observations.

What types of string distance metrics are appropriate and which are not appropriate?

How does exact matching perform on this data set? What about off-by-one matching?

How would you build a decision rule for matches/non-matches based upon scoring rules. What would your scoring rule be? Write this up.

Implement you scoring rule from Task 4 and compare it to exact and off-by-one matching. What are you findings?

Give insights into how you might be able to improve deterministic approaches moving forward if you re-did your analysis.