

## Module 5: Probabilistic Blocking, Part I

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# Agenda

- ▶ Data Cleaning Pipeline
- ▶ Blocking
- ▶ Probabilistic Blocking
- ▶ Locality Sensitive Hashing (LSH)
- ▶ Jaccard Similarity
- ▶ Shingling
- ▶ Putting it together
- ▶ Limitations

## Load R packages

```
if (!require("pacman")) {  
  install.packages("pacman")  
  library(pacman)  
}
```

```
## Loading required package: pacman
```

```
p_load(RecordLinkage,blink,knitr,cora,ggplot2,textreuse,tol)
```

```
## Installing package into '/Users/rebeccasteorts_1/Library'
```

```
## (as 'lib' is unspecified)
```

```
## also installing the dependency 'SnowballC'
```

```
##
```

```
## The downloaded binary packages are in
```

```
## /var/folders/bv/xhclmwh90zg08bvwnjvxtrz80000gp/T//Rtmp6
```

```
##
```

```
## tokenizers installed
```

```
{r, echo=TRUE, message=FALSE, warning=FALSE} #  
library(RecordLinkage) # library(blink) #  
library(knitr) # library(cora) #  
library(ggplot2) #
```

# Data Cleaning Pipeline

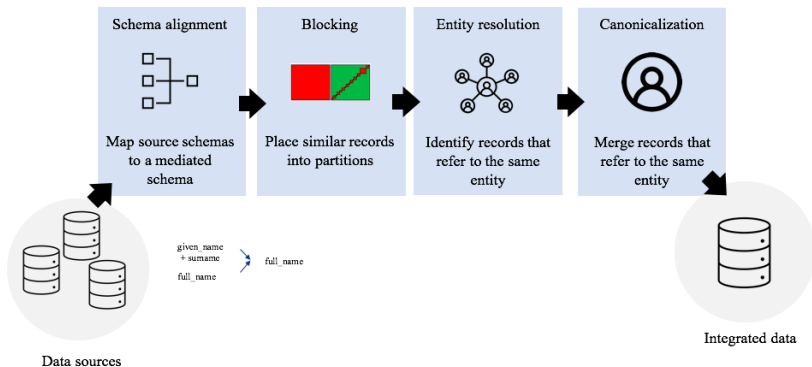


Figure 1: Data cleaning pipeline.

## Blocking

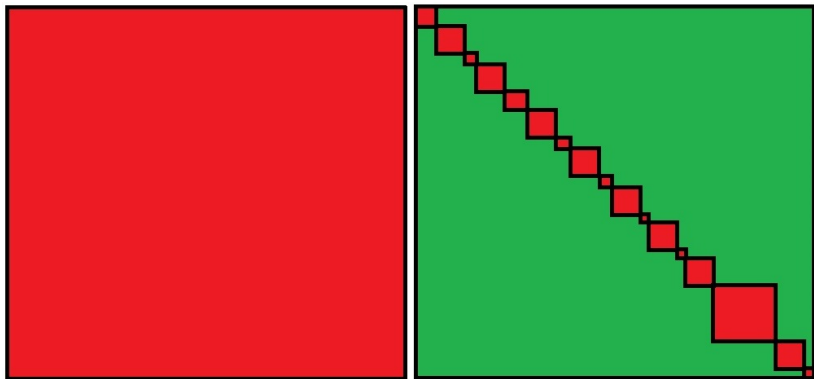


Figure 2: Left: All to all record comparison. Right: Example of resulting blocking partitions.

# LSH

Locality sensitive hashing (LSH) is a fast method of blocking for record linkage that originates from the computer science literature.

# Finding similar records

Our goal is to find *similar* records, where the records are assumed to be strings

How do we define *similar*?



## Jaccard similarity

We will work with the *Jaccard similarity*:

$$Jac(S, T) = \frac{|S \cap T|}{|S \cup T|}.$$

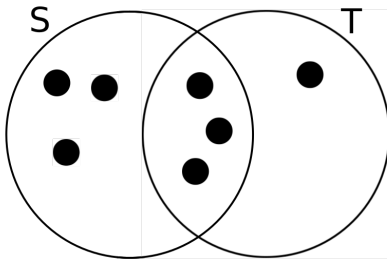


Figure 3: Two sets  $S$  and  $T$  with Jaccard similarity  $3/7$ . The two sets share 3 elements in common, and there are 7 elements in total.

# How to represent data as sets?

We want to talk about the similarity of our data (records)  $\Rightarrow$  we need to compare sets of records!

- ▶ We can construct a set of **short strings** from the data
- ▶ This is useful because similar datasets will have many common elements (common short strings)
- ▶ We can do construct these short strings using *shingling*

## $k$ -shingling (how-to)

1. Think of the data set as a string of characters
2. A  $k$ -shingle ( $k$ -gram) is any sub-string (word) of length  $k$  found within the a record of the data set
3. Associate with each data set the set of  $k$ -shingles that appear one or more times

## Let's try

Suppose our data set is the string “Hello world”, then

- ▶ the set of 2-shingles is {he, el, ll, lo, ow, wo, or, rl, ld}
- ▶ the set of 3-shingles is {hel, ell, llo, low, owo, wor, orl, rld}

## Your turn

We have the following two records:

```
# load RL data  
data("RLdata500")  
  
# select only 2 records  
records <- RLdata500[129:130, c(1,3)]  
names(records) <- c("First name", "Last name")  
  
# inspect records  
kable(records)
```

	First name	Last name
129	MICHAEL	VOGEL
130	MICHAEL	MEYER

## Your turn (continued)

1. Compute the 2-shingles for each record
2. Using Jaccard similarity, how similar are they?
3. What do you learn from this exercise?

## Your turn solution

**Do this on your own and compare with a partner.**

## Your turn solution

1. The 2-shingles for the first record are  
 $\{\text{mi, ic, ch, ha, ae, el, lv, vo, og, ge, el}\}$  and for the second are  
 $\{\text{mi, ic, ch, ha, ae, el, lm, me, ey, ye, er}\}$
2. There are 6 items in common  $\{\text{mi, ic, ch, ha, ae, el}\}$  and 15 items total  $\{\text{mi, ic, ch, ha, ae, el, lv, vo, og, ge, lm, me, ey, ye, er}\}$ , so the Jaccard similarity is  $\frac{6}{15} = \frac{2}{5} = 0.4$
3. You should have learned that this is very tedious to do by hand!



## Useful packages/functions in R

From the exercise, you should have learned that we don't want to do this by hand!

Here are some useful packages in R that can help us!

```
library(textreuse) # text reuse/document similarity  
library(tokenizers) # shingles
```

# Shingling

We can use the following functions to create  $k$ -shingles and calculate Jaccard similarity for our data

```
# get k-shingles  
tokenize_character_shingles(x, n)  
  
# calculate jaccard similarity for two sets  
jaccard_similarity(a, b)
```

## Your turn (solution)

```
# create shingles for both names
token.1 <-
  tokenize_character_shingles("MICHAELVOGEL", n=2)
token.2 <-
  tokenize_character_shingles("MICHAELMEYER", n=2)
# compute jaccard similarity
jaccard_similarity(unlist(token.1),unlist(token.2))

## [1] 0.4
```

# Citation Data Set

Research paper headers and citations, with information on authors, title, institutions, venue, date, page numbers and several other fields.

## Citation Data Set

```
data(cora) # load the cora data set
str(cora)  # structure of cora
```

```
## 'data.frame':    1879 obs. of  16 variables:
## $ id           : int   1 2 3 4 5 6 7 8 9 10 ...
## $ title        : 'noquote' chr  "Inganas and M.R" NA NA M
## $ book_title   : 'noquote' chr  NA NA NA NA ...
## $ authors      : 'noquote' chr  "M. Ahlskog, J. Paloheim
## $ address      : 'noquote' chr  NA NA NA NA ...
## $ date         : 'noquote' chr  "1994" "1994" "1994" "199
## $ year         : 'noquote' chr  NA NA NA NA ...
## $ editor       : 'noquote' chr  NA NA NA NA ...
## $ journal      : 'noquote' chr  "Andersson, J Appl. Phys
## $ volume       : 'noquote' chr  "76" "76" "76" "76" ...
## $ pages        : 'noquote' chr  "893" "893" "893" "893"
## $ publisher    : 'noquote' chr  NA NA NA NA ...
## $ institution  : 'noquote' chr  NA NA NA NA ...
## $ type         : 'noquote' chr  NA NA NA NA ...
## $ task         : 'noquote' chr  NA NA NA NA ...
```

## Your turn

Using the title, authors, and journal fields in the cora dataset,

1. Get the 3-shingles for each record (**hint:** use `tokenize_character_shingles`)
2. Obtain the Jaccard similarity between each pair of records (**hint:** use `jaccard_similarity`)

## Your turn (partial solution)

```
# get only the columns we want  
# number of records  
n <- nrow(cora)  
# create id column  
dat <- data.frame(id = seq_len(n))  
# get columns we want  
dat <- cbind(dat, cora[, c("title", "authors", "journal")])
```

Your turn (partial solution)

**Finish the rest of the exercise with a partner, which can be found after the summar**



## Summary

For a data set of size  $n$ , the number of comparisons we must compute is

$$\frac{n(n-1)}{2}.$$

For our set of records, we needed to compute 1,764,381 comparisons

For very large data sets, we need something faster (where we filter out records that are not similar).

A better approach for data sets of any realistic size is to use *hashing*, which we will look at next time.

## Your turn (Full solution)

```
# 1. paste the columns together and tokenize for each record
shingles <- apply(dat, 1, function(x) {
  # tokenize strings
  tokenize_character_shingles(paste(x[-1], collapse=" "), n = 3)
})
```

## Your turn (Full solution)

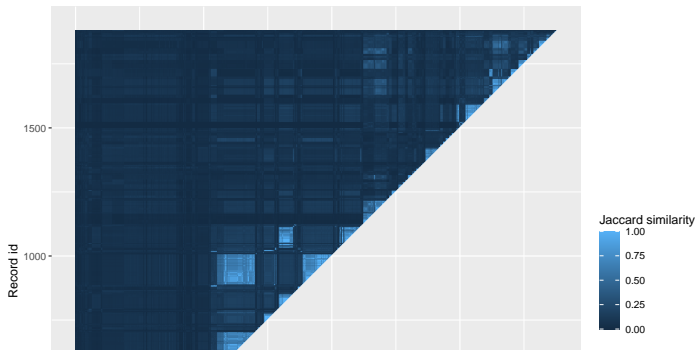
```
# 2. Jaccard similarity between pairs
# empty holder for similarities
jaccard <- expand.grid(record1 = seq_len(n),
                      record2 = seq_len(n))
# don't need to compare the same things twice
jaccard <- jaccard[jaccard$record1 < jaccard$record2,]
time <- Sys.time() # for timing comparison
jaccard$similarity <- apply(jaccard, 1, function(pair) {
  # get jaccard for each pair
  jaccard_similarity(shingles[[pair[1]]], shingles[[pair[2]]])
})
# timing
time <- difftime(Sys.time(), time, units = "secs")
```

This took took 72.32 seconds  $\approx$  1.21 minutes

## Your turn (solution, cont'd)

*# plot the jaccard similarities for each pair of records*

```
ggplot(jaccard) +  
  geom_raster(aes(x = record1, y = record2,  
                  fill=similarity)) +  
  theme(aspect.ratio = 1) +  
  scale_fill_gradient("Jaccard similarity") +  
  xlab("Record id") + ylab("Record id")
```



## Your turn (solution, cont'd)

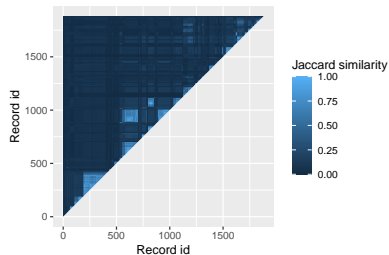


Figure 5: Jaccard similarity for each pair of records. Light blue indicates