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

```
library(RecordLinkage)
library(blink)
library(knitr)
library(cora)
library(ggplot2)
```

Data Cleaning Pipeline

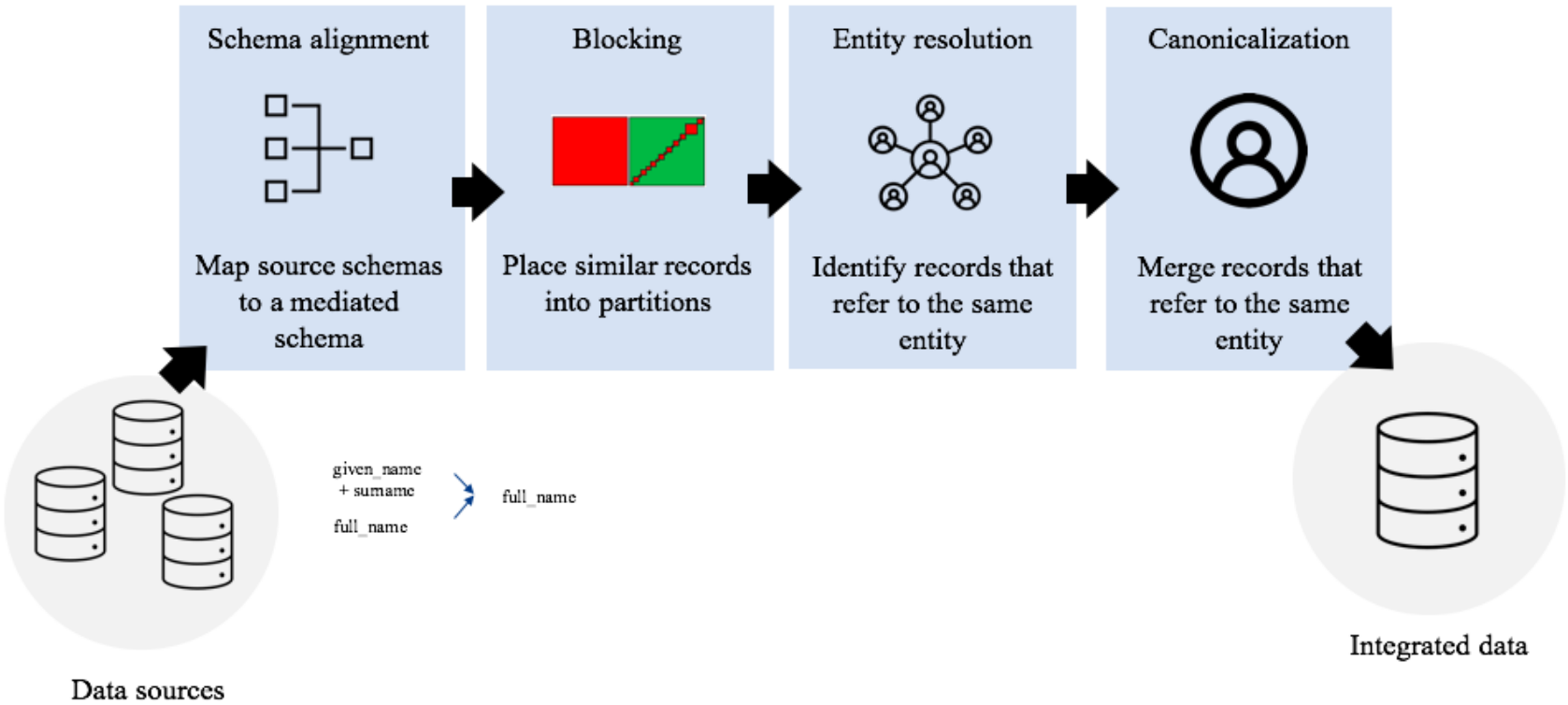


Figure 1: Data cleaning pipeline.

Blocking

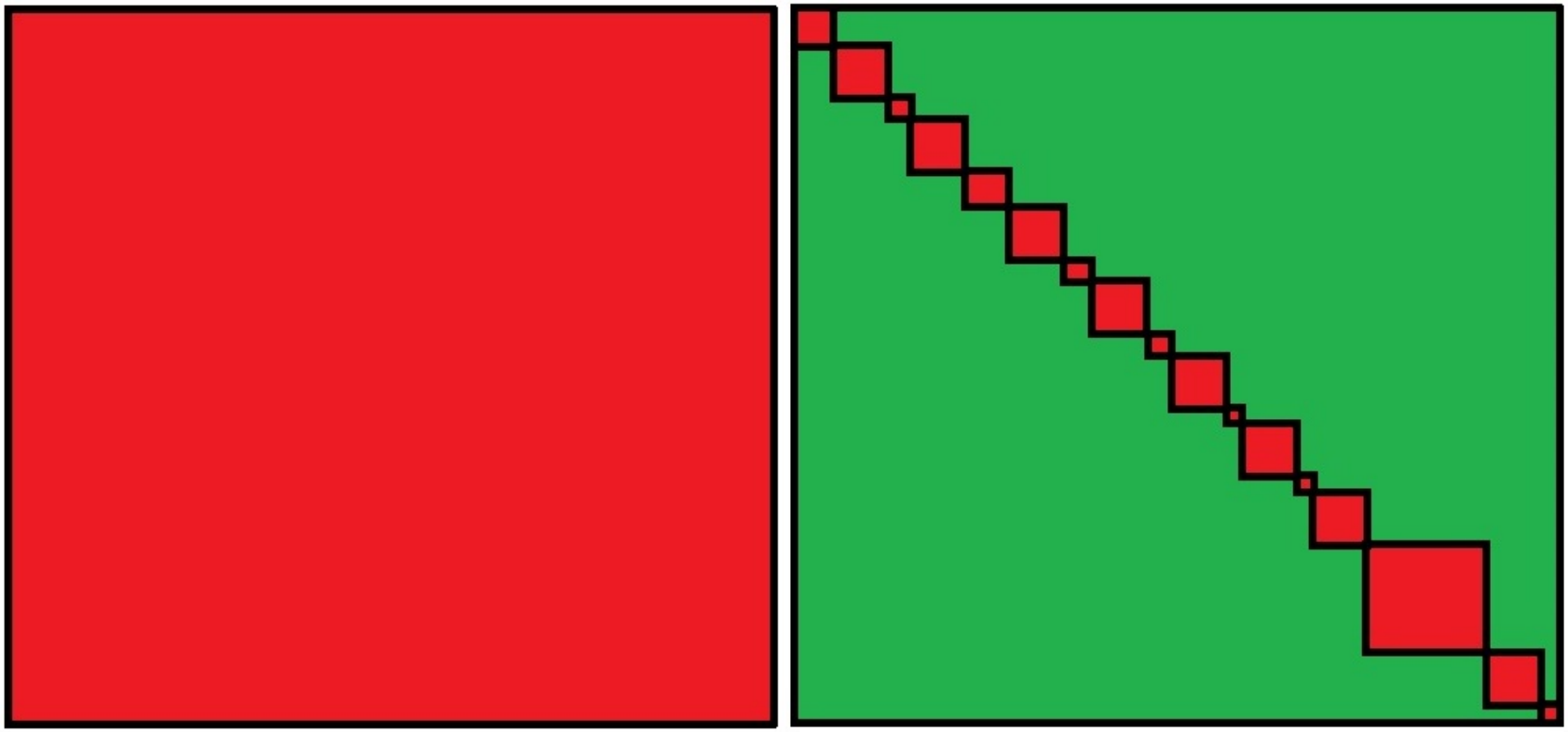


Figure 2: Left: All to all record comparison. Right: Example of resulting blocking partitions.

LSH

Locality sensitive hashing (LSH) is a fast method of blocking for record linkage that orginates 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*:

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

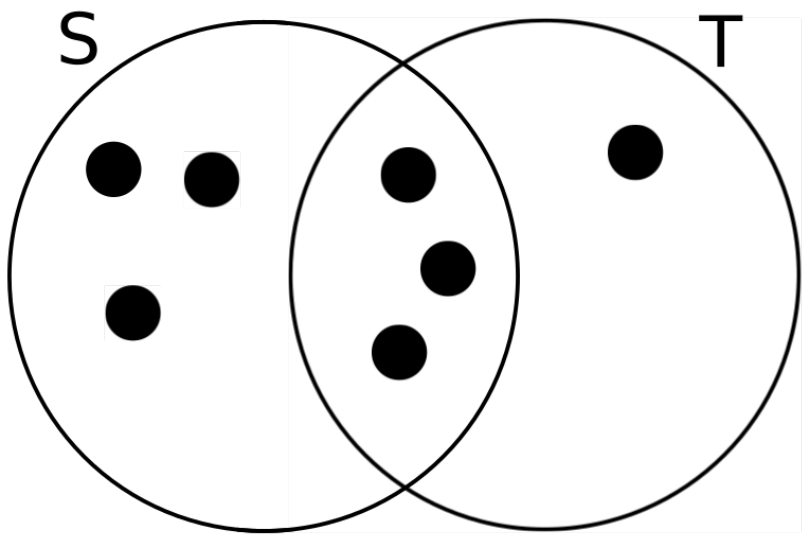


Figure 3: Two sets S and T with Jaccard similarity 3/7. The two sets share 3 elements in common, and there are 7 elements in total.

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.

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)
```

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 N
##  $ book_title  : 'noquote' chr  NA NA NA NA ...
##  $ authors     : 'noquote' chr  "M. Ahlskog, J. Paloheimo
##  $ 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 ...
```

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 (solution)

```r
# 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")])

# 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)
})
```

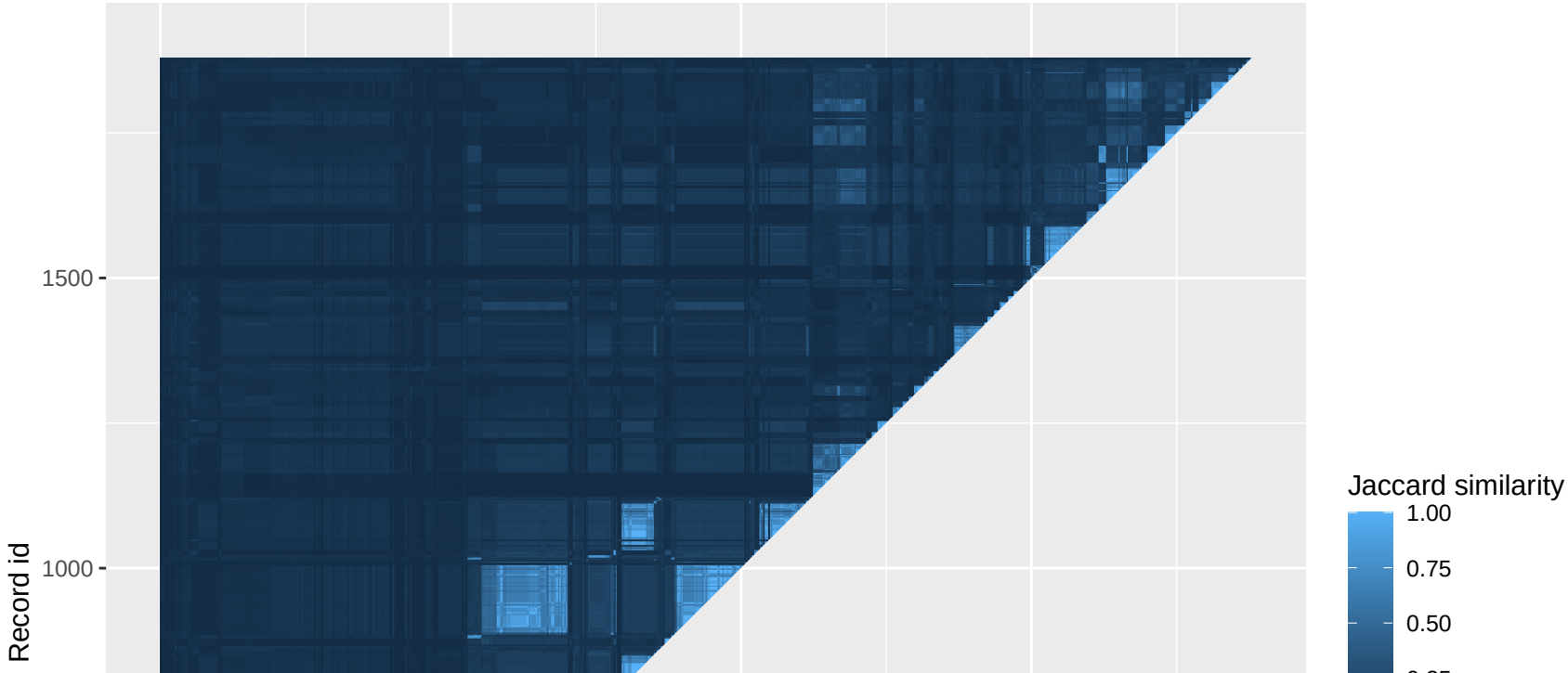
Your turn (solution)

```
# 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 108.7 seconds $\approx$ 1.81 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)

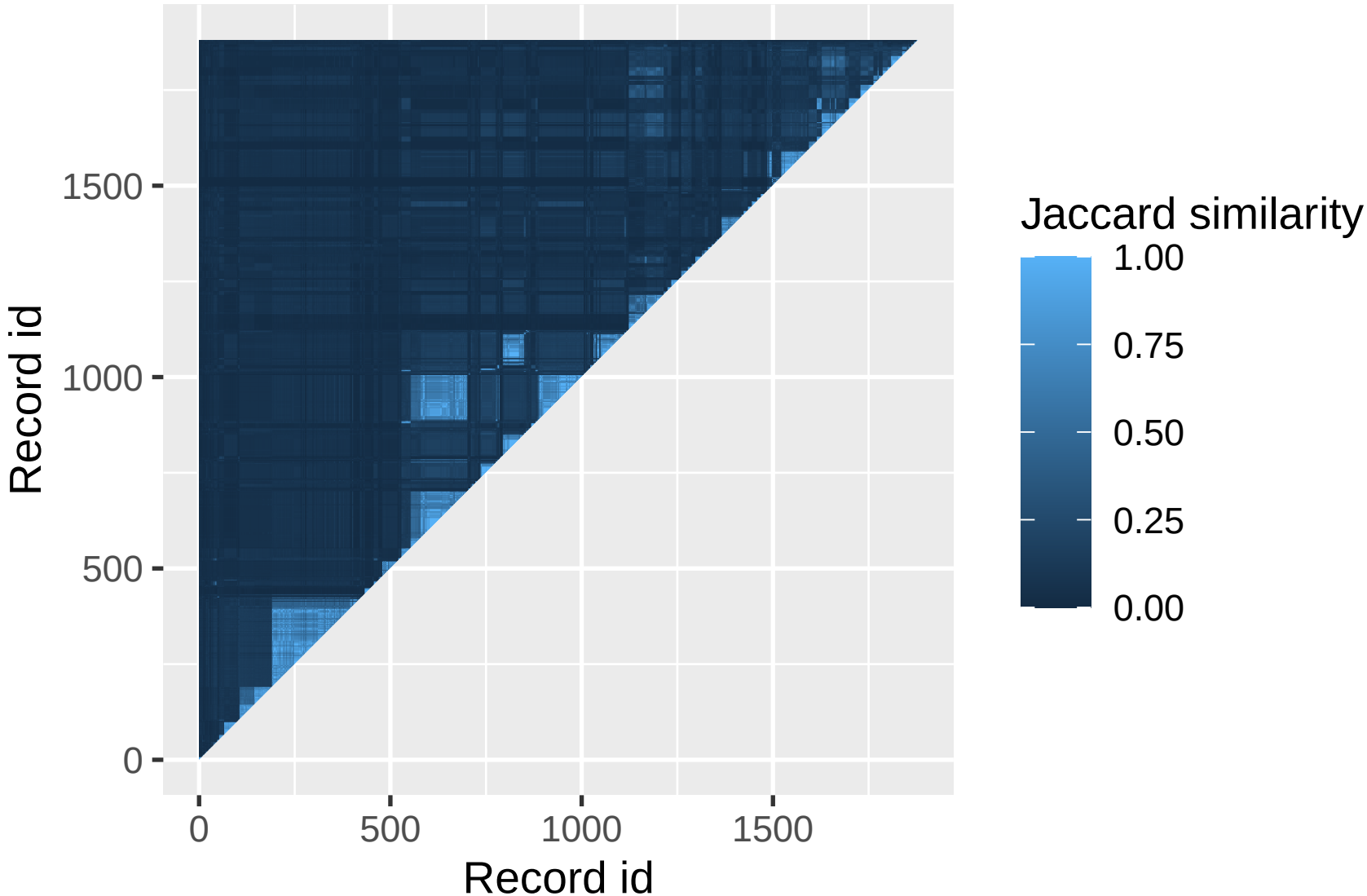


Figure 5: Jaccard similarity for each pair of records. Light blue indicates the two records are more similar and dark blue indicates less similar.

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.