Homework 3: Locality Sensitive Hashing

STA 325

2024-09-12

Consider the cora citation data set and load the data set with an column id as we did in class. Code is provided below.

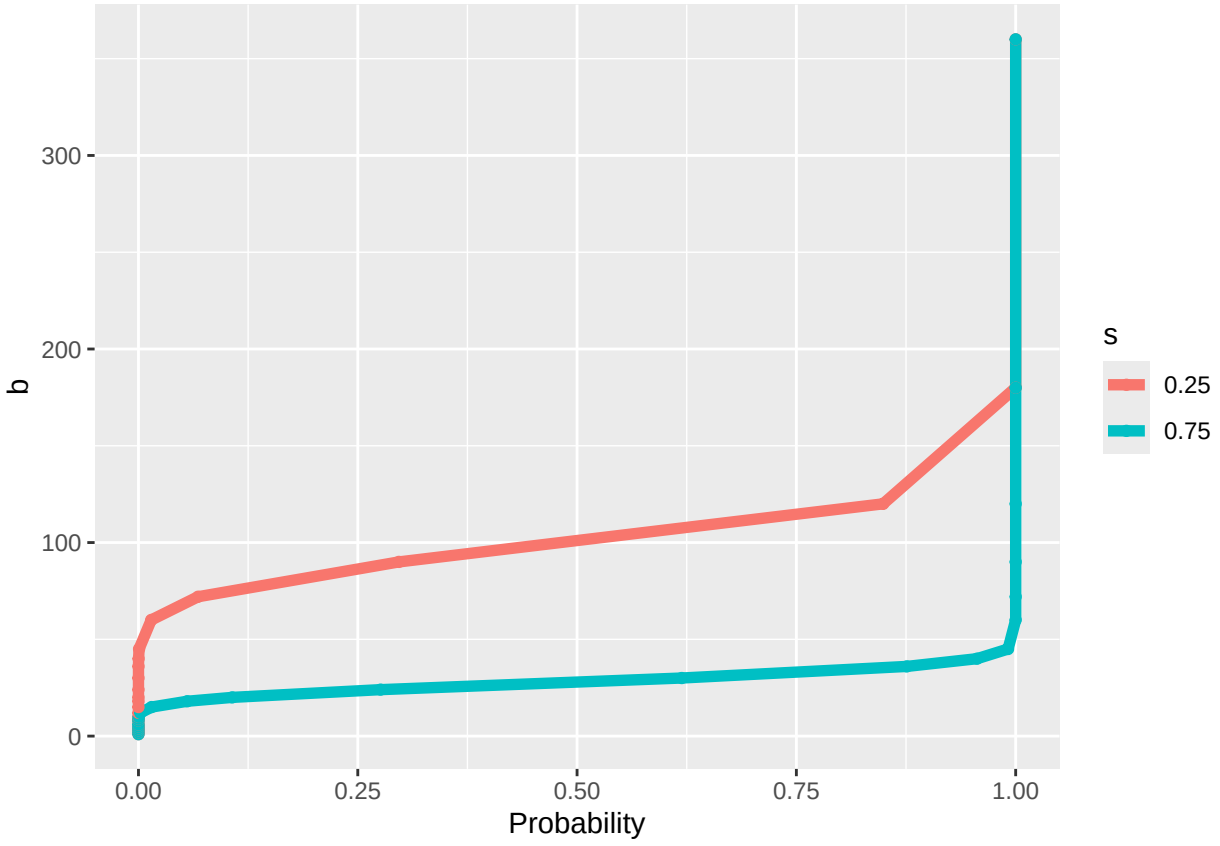
```
# get only the columns we want
# number of records
n <- nrow(cora)
# create id column
dat <- data.frame(id = seq_len(n))
# get columns we want
dat <- cbind(dat, cora[, c("title", "authors", "journal")])
```

Perform the LSH approximation as we did in class using the `textreuse` package via the functions `minhash_generator` and `lsh` (so we don't have to perform it by hand). Again, this code is provided for you given that it was done in class to make it a bit easier. Feel free to play around with this on your own. We will assume that m = 360, b = 90, and the number of shingles is 3 for this assignment.

Find the number of buckets or bands to use

```
library(numbers)
m <- 360
bin_probs <- expand.grid(s = c(.25, .75), h = m, b = divisors(m))
#bin_probs
# choose appropriate num of bands and number of random permutations m (tuning parameters)
bin_probs$prob <- apply(bin_probs, 1, function(x) lsh_probability(x[["h"]], x[["b"]], x[["s"]]))
# plot as curves
ggplot(bin_probs) +
  geom_line(aes(x = prob, y = b, colour = factor(s), group = factor(s)), linewidth = 2) +
  geom_point(aes(x = prob, y = b, colour = factor(s)), linewidth = 3) +
  xlab("Probability") +
  scale_color_discrete("s")
```

```
## Warning in geom_point(aes(x = prob, y = b, colour = factor(s)), linewidth = 3):
## Ignoring unknown parameters: `linewidth`
```




```
# create the minhash function
minhash <- minhash_generator(n = m, seed = 02082018)
b <- 90
```

Build corpus and perform shingling

```
head(dat)
```

```
##   id           title
## 1  1 Inganas and M.R
## 2  2            <NA>
## 3  3            <NA>
## 4  4            <NA>
## 5  5            <NA>
## 6  6            <NA>
##                                                                                 authors
## 1                                M. Ahlskog, J. Paloheimo, H. Stubb, P. Dyreklev, M. Fahlman, O
## 2 M. Ahlskog, J. Paloheimo, H. Stubb, P. Dyreklev, M. Fahlman, O. Inganas and M.R.   Andersson
## 3 M. Ahlskog, J. Paloheimo, H. Stubb, P. Dyreklev, M. Fahlman, O.  Inganas and M.R.  Andersson
## 4   M. Ahlskog, J. Paloheimo, H. Stubb, P. Dyreklev, M. Fahlman, O. Inganas and M.R. Andersson
## 5  M. Ahlskog, J. Paloheimo, H. Stubb, P. Dyreklev, M. Fahlman, O.  Inganas and M.R. Andersson
## 6   M. Ahlskog, J. Paloheimo, H. Stubb, P. Dyreklev, M. Fahlman, O. Inganas and M.R. Andersson
##                    journal
## 1 Andersson, J Appl. Phys.
## 2             JAppl. Phys.
## 3            J Appl. Phys.
```

```
## 4             J Appl.Phys.
## 5            J Appl. Phys.
## 6             J Appl.Phys.
```

```
# build the corpus using textreuse
docs <- apply(dat, 1, function(x) paste(x[-1], collapse = " ")) # get strings
names(docs) <- dat$id # add id as names in vector
corpus <- TextReuseCorpus(text = docs, # dataset
                          tokenizer = tokenize_character_shingles, n = 3,
                          simplify = TRUE, # shingles
                          progress = FALSE, # quietly
                          keep_tokens = TRUE, # store shingles
                          minhash_func = minhash) # use minhash
head(minhashes(corpus[[1]]))
```

```
## [1] -2064207635 -2111669997 -2125164234 -2097867716 -2144942958 -2116065215
```

```
length(minhashes(corpus[[1]]))
```

```
## [1] 360
```

Note that all our records are now represented by 360 randomly selected and hashed shingles. Comparing these shingles are equivalent to finding the Jaccard similarity of all the record pairs. We still have an issue of all the pairwise comparison.

Find buckets, candidate records, and Jaccard similarity

Now, we find the buckets, candidates records, and calculate the Jaccard similarity for the candidate records (in the buckets)

```
# perform lsh to get buckets
buckets <- lsh(corpus, bands = b, progress = FALSE)
```

```
## Warning: `gather_()` was deprecated in tidyr 1.2.0.
## i Please use `gather()` instead.
## i The deprecated feature was likely used in the textreuse package.
##   Please report the issue at <https://github.com/ropensci/textreuse/issues>.
## This warning is displayed once every 8 hours.
## Call `lifecycle::last_lifecycle_warnings()` to see where this warning was
## generated.
```

```
# grab candidate pairs
candidates <- lsh_candidates(buckets)

# get Jaccard similarities only for candidates
lsh_jaccard <- lsh_compare(candidates, corpus,
                           jaccard_similarity, progress = FALSE)
head(buckets)
```

```
## # A tibble: 6 x 2
##   doc   buckets
##   <chr> <chr>
## 1 1     fb93d6f4c56666ec8210570af8e8edd0
## 2 1     cf942dbe840d4365cf182ea24d6951c8
## 3 1     e9535be0f24e39103ba1f11442cc170e
## 4 1     52a293069e3920a0f56e38a0f0c6af37
## 5 1     b751d8b2d24bec53a78b3043dc017837
## 6 1     0ce07d00e8c2e811204352b51229ed18
```

```
dim(buckets)
```

```
## [1] 169110      2
```

```
length(unique(buckets))
```

```
## [1] 2
```

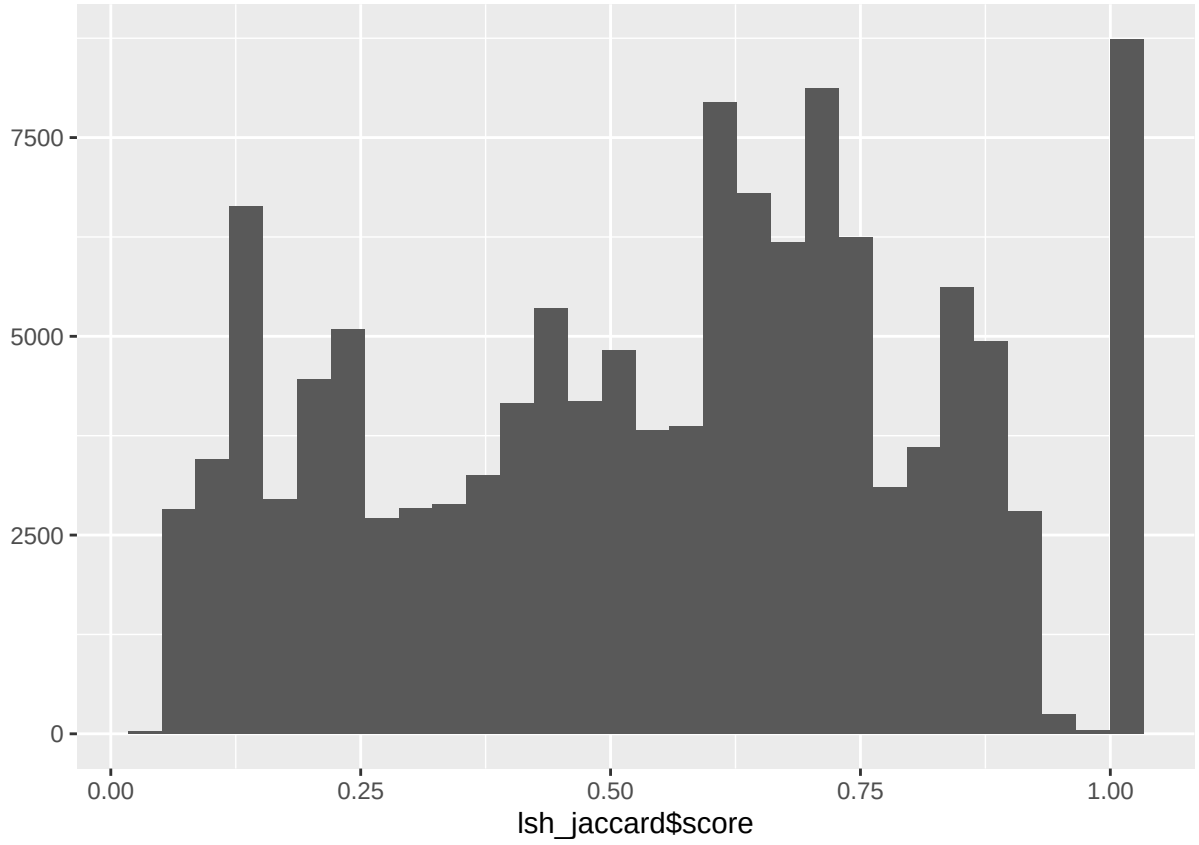
```
head(lsh_jaccard)
```

```
## # A tibble: 6 x 3
##   a     b     score
##   <chr> <chr> <dbl>
## 1 1     2     0.865
## 2 1     3     0.865
## 3 1     4     0.865
## 4 1     5     0.865
## 5 1     6     0.865
## 6 1     7     0.865
```

We now plot the Jaccard similarities that are candidate pairs (under LSH)

```
## Warning: `qplot()` was deprecated in ggplot2 3.4.0.
## This warning is displayed once every 8 hours.
## Call `lifecycle::last_lifecycle_warnings()` to see where this warning was
## generated.
```

```
## `stat_bin()` using `bins = 30`. Pick better value with `binwidth`.
```



1. Calculate the reduction ratio from the total number of record comparisons (N choose 2) compared to those under locality sensitive hashing (above).
2. Find the pairwise precision and recall under locality sensitive hashing. There are two places where we have ground truth. Note that cora_gold contains record pairs that are true matches; cora_gold_update contains a unique identifer alternatively. You will need to write your own code for this.

Hint: the lsh_jaccard contains our pairwise predictions and cora_gold contains the pairwise truth. How can you compare the pairs in lsh_jaccard and the pairs in cora_gold to find the number of true positives first? Then, how can you extend this to find the other components of precision and recall? There are multiple ways to approach this problem, but examining the data pairwise may be the most intuitive.

3. We can further reduce the problem by filtering out candidate pairs of records below a threshold t that are unlikely to be matches. For example, assume $t = 0.8$. Filter out all record pairs below the threshold of 0.8. We will call this locality sensitive hashing with filtering/thresholding.
4. Under lsh with t = 0.8, re-compute the precision, recall, and reduction ratio.
5.

i. Describe what the blocks look like from this method? Hint: Try looking at a histogram of the number of records in each bucket.

ii. Are the blocks non-overlapping or overlapping? Hint: Part (i) should help you determine an answer to this.

iii. Describe some advantages and disadvantages of the LSH method that you see from using it practically.