

blocking: An R Package for Blocking of Records for Record Linkage and Deduplication

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Abstract Entity resolution (probabilistic record linkage, deduplication) is essential for estimation based on multiple sources. It aims to link records without common identifiers that refer to the same entity (e.g., person, company). Without identifiers, researchers must specify which records to compare to calculate matching probability and reduce computational complexity. Traditional deterministic blocking uses common variables like names or dates of birth, but assumes error-free, complete data. To address this limitation, we developed the R package **blocking**, which uses approximate nearest neighbour search and graph algorithms to reduce number of comparisons. This paper presents the package design, functionalities, and two case studies.

1 Introduction

1.1 Blocking for record linkage

Entity resolution (probabilistic record linkage, deduplication) is essential for estimation based on multiple sources (cf. [Fellegi and Sunter \(1969\)](#), [Binette and Steorts \(2022\)](#)). The goal is to link records without common identifiers that refer to the same entity (e.g., person, company, job position). This situation is often observed in administrative records, particularly for foreign-born populations. For instance, the Social Insurance Institution register in Poland at the end of 2023 included 1.206 million records which referred to possibly 1.105 million individuals, of which about 10% had missing information in the personal identifier (PESEL) and about 50% of cases had missing address details. Note that the exact number of individuals will certainly be lower than 1.105 million as the 10% may include duplicates (cf. [Beręsewicz \(2025\)](#)).

This drives a need to link records without identifiers but often requires certain assumptions such as how to reduce the large number of possible comparisons, as it is not possible to compare all pairs of records in a large dataset (e.g., for the mentioned example this would lead to over 600 billion comparisons). That is why researchers aim to reduce the number of comparisons in various ways prior to the record linkage/deduplication stage. The reason for this is twofold: computational resources and clerical review workload.

Reducing the number of comparisons is done by blocking, which is a method of reducing the number of possible comparisons by assuming that certain variables should be exactly matched or some of their combinations should match at a certain threshold. For instance, a standard method is based on assuming that sex or age should match exactly while other characteristics of the records could be varying. Another method is to use phonetic algorithms such as Soundex (cf. [Wright, 1960](#)) or its improvements for non-English languages (cf. [Howard, II, 2020](#)). Furthermore, due to the use of large language models, one may also consider using embeddings ([Mikolov et al., 2013](#)) to search for the closest neighbour and treat this as a possible comparison pair. For a general review of blocking methods see [Steorts et al. \(2014\)](#) or [Papadakis et al. \(2020\)](#). In Section 1.2 we will discuss existing R packages that implement blocking methods.

Reducing the number of pairs has its costs: missing comparisons which lead to an increased false positive rate (FPR) and false negative rate (FNR) of the linkage study. In order to assess this error, a subset of true pairs should be provided or simulation studies of proposed methods should be conducted. Alternatively, one may consider approaches proposed by [Dasylyva and Goussanou \(2021\)](#) and [Dasylyva and Goussanou \(2022\)](#) who

showed how to estimate FPR and FNR without access to an audit sample.

1.2 Existing software and our contribution

The R ecosystem offers several packages that implement various blocking techniques which we grouped by the following classification:

- **deterministic blocking:**
 - **reclin2** (van der Laan, 2024, van der Laan (2022)) which allows pairing records using the `pair_blocking()` with a prespecified list of columns in a `data.frame`, and the `pair_minsim()` function that allows specifying the minimal similarity score (e.g., 1 out of 3 variables should match exactly).
 - **RecordLinkage** (Sariyar and Borg, 2025, Sariyar and Borg (2010)) which allows specifying blocking variables in the `blockfld` in either `compare.dedup()` or `compare.linkage()` functions in the form of a vector (either character or numeric).
 - **fastLink** (Enamorado et al., 2023, Enamorado et al. (2019)) which implements various blocking methods via the `blockData()` function such as exact matching, window matching (e.g., no more than 2 years difference between birth year), or k-means clustering algorithm. It should be noted that `fastLink` returns split dataset(s) into separate lists while `reclin2` and `RecordLinkage` packages create a single dataset.
- **phonetic blocking:**
 - **RecordLinkage** allows directly specifying the phonetic comparison via the `phonetic` argument of the `compare.dedup()` or `compare.linkage()` function via the `soundex()` function. However, this is not used for blocking but for comparison of strings.
 - It should be noted that **stringdist** (van der Loo, 2014) also implements the SOUNDEX algorithm while the **phonics** (Howard, II, 2021, Howard, II (2020)) implements various phonetic algorithms that could be applied prior to the blocking procedure (e.g., create a new column).
- **probabilistic blocking:**
 - **klsh** (Steorts, 2020) is the only R package that implements probabilistic blocking using the k-means variant of locality sensitive hashing. The main `klsh()` function implements this approach and the resulting object is a list with row identifiers for the prespecified number of blocks (via the `num.blocks` argument of the `klsh()` function).

Unfortunately, practice is more complicated as missing data can be present in blocking/matching variables (such as birth date) or typos in names and surnames. That is why we decided to develop **blocking** that leverages approximate nearest neighbour (ANNs) algorithms and graphs to create a large number of small blocks that can be further used in the analysis (this is also somehow similar to micro-clustering, cf. Johndrow et al. (2018)). The basic idea behind the **blocking** package can be expressed in the following steps:

1. create shingles of the input character vectors via the **tokenizers** (Mullen et al., 2018) and **text2vec** (Selivanov et al., 2023) packages or provide a matrix of vectors (e.g., embeddings via the **ragnar** (Kalinowski and Falbel, 2025) package) that represent the input character vectors.
2. search for nearest neighbours using ANNs implemented in the **rnnDescent** (Melville, 2024b), **RcppHNSW** (Melville, 2024a), **mlpack** (Curtin et al., 2023, Singh Parihar et al. (2025)), and **RcppAnnoy** (Eddelbuettel, 2024).
3. create final blocks using **igraph** (Csárdi et al., 2025, Csardi and Nepusz (2006)).

This is the only package in the R ecosystem that allows easily applying modern ANNs algorithms to reduce number of comparisons and significantly speed up the record linkage / deduplication problems. In addition, we have developed the `pair_ann()` function to seamlessly integrate with the **reclin2** package which is described in one of the package vignettes.

1.3 Outline of article

The paper has the following structure. In the Section 2 we provide description of the main functionalities of the **blocking** package and how we can assess results. In the Section 3 we provide two case studies: probabilistic record linkage and deduplication. These examples show how our package can improve pipeline of entity resolution and works with existing R packages.

2 Blocking of records using blocking function

2.1 The main function

The main functionality is available via the `blocking()` function which contains the following main arguments:

- `x`, `y` – reference vectors, where `y = NULL` which indicates that the deduplication is applied,
- `representation` – whether `x` and `y` should be represented as shingles or vectors (e.g., provided by the user in the `model` argument),
- `ann` – which ANN algorithm should be applied, by default we use the **rnndescent** package as it supports sparse matrices,
- `distance` – which distance should be applied (default is cosine distance),
- `graph` – whether the plot of the graph of connected records should be returned (default FALSE),
- `true_blocks` – if a subset of true blocks is available it can be provided here so the measures of quality, presented in the next section, are returned,
- `n_threads` – how many threads are applied for computation,
- `control_txt` – controls provided in the `controls_txt()` on how the `x`, `y` are processed,
- `control_ann` – controls provided in the `controls_ann()` allow user to fine-tune ANN algorithm (see documentation of the `controls_ann()` function and `control_*` functions with the names referring to a specific algorithm, e.g., `control_nnd()` for the NND algorithm).

This function returns an object of the `blocking` class with the following elements:

- `result` – a `data.table` with indices (rows) of `x`, `y`, `block` and distance between points
- `method` – name of the ANNs algorithm used,
- `deduplication` – information whether deduplication was applied,
- `representation` – information whether shingles or vectors were used,
- `metrics` – metrics for quality assessment, if `true_blocks` is provided,
- `confusion` – confusion matrix, if `true_blocks` is provided,
- `colnames` – variable names (`colnames`) used for search,
- `graph` – an `igraph` class object.

2.2 Assessment of results

In the package we have implemented several measures that can be used to assess the results. The first one is the *reduction ratio* (RR) which is an indicator of the reduction in comparison

pairs in the given blocks. It has a value between $[0, 1]$, where 1 indicates perfect reduction while values close to 0 indicate that the reduction is rather poor.

This RR indicator of the deduplication has the following form

$$RR_{\text{dedup}} = 1 - \frac{\sum_{i=1}^k \binom{|B_i|}{2}}{\binom{n}{2}},$$

where k is the total number of blocks, n is the total number of records in the dataset, and $|B_i|$ is the number of records in the i -th block. $\sum_{i=1}^k \binom{|B_i|}{2}$ is the number of comparisons after blocking, while $\binom{n}{2}$ is the total number of possible comparisons without blocking. For record linkage the reduction ratio is defined as follows

$$RR_{\text{reclin}} = 1 - \frac{\sum_{i=1}^k |B_{i,x}| \cdot |B_{i,y}|}{m \cdot n},$$

where m and n are the sizes of datasets X and Y , and k is the total number of blocks. The term $|B_{i,x}|$ is the number of unique records from dataset X in the i -th block, while $|B_{i,y}|$ is the number of unique records from dataset Y in the i -th block. The expression $\sum_{i=1}^k |B_{i,x}| \cdot |B_{i,y}|$ is the number of comparisons after blocking.

Another way to assess the blocking is to study the confusion matrix at the *block* level, i.e., results of blocking are compared in comparison to ground-truth *blocks* in a pairwise manner (e.g., one true positive pair occurs when both records from the comparison pair belong to the same predicted *block* and to the same ground-truth *block* in the evaluation data. frame). The values in this table are defined as follows

- True Positive (TP): record pairs correctly matched in the same block.
- False Positive (FP): record pairs identified as matches that are not true matches in the same block.
- True Negative (TN): record pairs correctly identified as non-matches (different blocks).
- False Negative (FN): record pairs identified as non-matches that are true matches in the same block.

Metrics calculated based on this confusion matrix are presented in Table 1.

Table 1: Evaluation Metrics

Metric	Formula	Metric	Formula
Recall	$\frac{TP}{TP+FN}$	Accuracy	$\frac{TP+TN}{TP+TN+FP+FN}$
Precision	$\frac{TP}{TP+FP}$	Specificity	$\frac{TN}{TN+FP}$
F1 Score	$2 \cdot \frac{\text{Precision} \times \text{Recall}}{\text{Precision} + \text{Recall}}$	False Positive Rate	$\frac{FP}{FP+TN}$
False Negative Rate	$\frac{FN}{FN+TP}$		

3 Case studies

3.1 An example of blocking for record linkage

Let us first load the required packages.

```
library("blocking")
library("data.table")
library("reclin2")
```

We demonstrate the use of `blocking()` function for record linkage on the foreigners dataset included in the package. This fictional representation of the foreign population in Poland was generated based on publicly available information, preserving the distributions from administrative registers. It contains 110,000 rows with 100,000 entities (thus contains 10,000 duplicates). Each row represents one record, with the following columns: `fname` – first name, `sname` – second name, `surname` – surname, `date` – date of birth, `region` – region (county), `country` – country, and `true_id` – a person identifier.

Next, we load the data and examine the first 6 records.

```
data("foreigners")
head(foreigners)
```

#>	fname	sname	surname	date	region	country	true_id
#>	<char>	<char>	<char>	<char>	<char>	<char>	<num>
#> 1:	emin		imanov	1998/02/05		031	0
#> 2:	nurlan		suleymanli	2000/08/01		031	1
#> 3:	amio		maharrsmov	1939/03/08		031	2
#> 4:	amik		maharramof	1939/03/08		031	2
#> 5:	amil		maharramov	1993/03/08		031	2
#> 6:	gadir		jahangirov	1991/08/29		031	3

In the next step, we split the dataset into two separate data.frames: one containing the first appearance of each entity in the foreigners dataset, and the other containing its subsequent appearances and add row identifiers (`x` and `y`).

```
foreigners_1 <- foreigners[!duplicated(foreigners>true_id), ]
foreigners_1[, x := 1:.N]
foreigners_2 <- foreigners[duplicated(foreigners>true_id), ]
foreigners_2[, y := 1:.N]
```

Now, in both datasets we remove separators from the date column and create a new character column that concatenates the information from all columns (excluding `true_id`) in each row. Information stored in the `txt` column will be used for blocking records in the `blocking()` function.

```
foreigners_1[, txt := paste0(fname, sname, surname, gsub("/", "", date),
                             region, country)]
foreigners_2[, txt := paste0(fname, sname, surname, gsub("/", "", date),
                             region, country)]
head(foreigners_1[, .(true_id, txt)])
```

#>	true_id	txt
#>	<num>	<char>
#> 1:	0	eminimanov19980205031
#> 2:	1	nurlansuleymanli20000801031
#> 3:	2	amio maharrsmov19390308031
#> 4:	3	gadirjahangirov19910829031
#> 5:	4	zaurbayramova1996100601261031
#> 6:	5	asifmammadov19970726031

The default algorithm is the Nearest Neighbour Descent Method (Dong et al., 2011) implemented in the `rnn descent` package. Additionally, we set `verbose = 1` to monitor progress. Note that a default parameter of the `blocking()` function is `seed = 2023`, which sets the random seed (`t: 1232` denotes how many 2 character shingles were created).

```
result_reclin <- blocking(x = foreigners_1$txt,
                          y = foreigners_2$txt,
                          verbose = 1)
```

```
#> ===== creating tokens =====
#> ===== starting search (nnd, x, y: 100000, 10000, t: 1232) =====
#> ===== creating graph =====
```

Now, we can examine the results by printing the `result_reclin` object. In this example we have created 6,470 blocks based on 1,232 columns (2 character shingles). Blocks are small as we have 3,920 blocks of 2 elements, 1,599 blocks of 3 elements, ... , 2 blocks of 7 elements.

```
result_reclin
```

```
#> =====
#> Blocking based on the nnd method.
#> Number of blocks: 6470.
#> Number of columns used for blocking: 1232.
#> Reduction ratio: 0.9999.
#> =====
#> Distribution of the size of the blocks:
#>      2      3      4      5      6      7
#> 3920 1599  928   19      2      2
```

In order to access the result one should use `result_reclin$result`. The resulting `data.table` has four columns (as presented below):

- `x` – reference dataset (i.e. `foreigners_1`) – this may not contain all units of `foreigners_1`,
- `y` – query (each row of `foreigners_2`) – this will contain all units of `foreigners_2`,
- `block` – the block identifier,
- `dist` – distance between pairs.

```
head(result_reclin$result)
```

```
#>      x      y block      dist
#>   <int> <int> <num>   <num>
#> 1:     3     1     1 0.2216882
#> 2:     3     2     1 0.2122737
#> 3:    21     3     2 0.1172652
#> 4:    57     4     3 0.1863238
#> 5:    57     5     3 0.1379310
#> 6:    61     6     4 0.2307692
```

Let's examine the first block. Obviously, there are typos in the `fname` and `surname`. Nevertheless, all records refer to the same entity (as denoted by `true_id`).

```
rbind(foreigners_1[3, 1:7], foreigners_2[1:2, 1:7])
```

```
#>      fname  sname      surname      date region country true_id
#>   <char> <char>   <char>   <char> <char>  <char>  <num>
#> 1:   amio      maharrsmov 1939/03/08      031      2
#> 2:   amik      maharramov 1939/03/08      031      2
#> 3:   amil      maharramov 1993/03/08      031      2
```

Now we use the `true_id` column to evaluate our approach.

```
matches <- merge(x = foreigners_1[, .(x, true_id)],
                 y = foreigners_2[, .(y, true_id)],
                 by = "true_id")
matches[, block := rleid(x)]
head(matches)
```

```
#> Key: <true_id>
#>   true_id    x    y block
#>   <num> <int> <int> <int>
#> 1:      2     3     1     1
#> 2:      2     3     2     1
#> 3:     20    21     3     2
#> 4:     56    57     4     3
#> 5:     56    57     5     3
#> 6:     60    61     6     4
```

We have 10,000 matched pairs which can be used in the `true_blocks` argument in the `blocking()` function to specify the true block assignments. We obtain the quality metrics for the assessment of record linkage.

```
res_reclin <- blocking(x = foreigners_1$txt,
                      y = foreigners_2$txt,
                      verbose = 1,
                      true_blocks = matches[, .(x, y, block)])

#> ===== creating tokens =====
#> ===== starting search (nnd, x, y: 100000, 10000, t: 1232) =====
#> ===== creating graph =====

res_reclin

#> =====
#> Blocking based on the nnd method.
#> Number of blocks: 6470.
#> Number of columns used for blocking: 1232.
#> Reduction ratio: 0.9999.
#> =====
#> Distribution of the size of the blocks:
#>    2    3    4    5    6    7
#> 3920 1599  928   19     2     2
#> =====
#> Evaluation metrics (standard):
#>   recall  precision      fpr      fnr  accuracy specificity
#>   96.7532   78.6700   0.0038   3.2468   99.9957   99.9962
#>   f1_score
#>   86.7795
```

For example, our approach results in a 3.25% FNR. To improve this, we can increase the `epsilon` parameter of the NND method from 0.1 to 0.5. To do so, we configure the `control_ann` parameter in the `blocking()` function using the `controls_ann()` and `control_nnd()` functions.

```
res_reclin2 <- blocking(x = foreigners_1$txt,
                       y = foreigners_2$txt,
                       verbose = 1,
                       true_blocks = matches[, .(x, y, block)],
                       control_ann = controls_ann(nnd = control_nnd(epsilon = 0.5)))

#> ===== creating tokens =====
#> ===== starting search (nnd, x, y: 100000, 10000, t: 1232) =====
#> ===== creating graph =====

res_reclin2
```

```
#> =====
#> Blocking based on the nnd method.
#> Number of blocks: 6394.
#> Number of columns used for blocking: 1232.
#> Reduction ratio: 0.9999.
#> =====
#> Distribution of the size of the blocks:
#>    2    3    4    5    7
#> 3800 1615  954   21    4
#> =====
#> Evaluation metrics (standard):
#>      recall  precision      fpr      fnr  accuracy specificity
#>    96.8776    80.0500    0.0036    3.1224    99.9960    99.9964
#>    f1_score
#>    87.6636
```

That decreases the FNR to 3.12%.

Now, to use the result in the record linkage process by adding this information to both datasets and specifying it in the appropriate argument of a given function. Below we present an example using the `reclin2` package using a simple score.

```
foreigners_1[res_reclin2$result, on = "x", block:= i.block]
foreigners_2[res_reclin2$result, on = "y", block:= i.block]

pair_blocking(x = foreigners_1,
              y = foreigners_2, on = "block") |>
  compare_pairs(on = c("fname", "surname", "date"),
               default_comparator = cmp_jarowinkler()) |>
  score_simple("score", on = c("fname", "surname", "date")) |>
  head(n= 4)

#> First data set: 100 000 records
#> Second data set: 10 000 records
#> Total number of pairs: 4 pairs
#> Blocking on: 'block'
#>
#>      .x  .y  fname  surname  date  score
#>    <int> <int>    <num>    <num>    <num>    <num>
#> 1:     3   1 0.8333333 0.8666667 1.0000000 2.700000
#> 2:     3   2 0.8333333 0.9333333 0.9666667 2.733333
#> 3:    21   3 0.8333333 0.9166667 1.0000000 2.750000
#> 4:    57   4 0.9259259 0.9259259 0.9666667 2.818519
```

3.2 An example of blocking for deduplication

In this section we demonstrate deduplication application using the `blocking()` function on the `RLdata500` dataset from the **RecordLinkage** package. Note that the dataset is included in the `blocking` package. It contains artificial personal data and fifty records have been duplicated with randomly generated errors. Each row represents one record, with the following columns: `fname_c1` – first name, `fname_c2` – second name, `lname_c1` – last name, `lname_c2` – last name (second component), `by`, `bm`, `bd` – year, month and day of birth, `rec_id` – record id, and `ent_id` – entity id.

```
data("RLdata500")
head(RLdata500)
```



```
#>   fname_c1 fname_c2 lname_c1 lname_c2   by   bm   bd rec_id ent_id
#>   <char>  <char>  <char>  <char> <int> <int> <int> <int> <int>
#> 1:  CARSTEN          MEIER      1949    7   22     1    34
#> 2:    GERD          BAUER      1968    7   27     2    51
#> 3:  ROBERT      HARTMANN      1930    4   30     3   115
#> 4:  STEFAN          WOLFF      1957    9    2     4   189
#> 5:    RALF      KRUEGER      1966    1   13     5    72
#> 6: JUERGEN          FRANKE      1929    7    4     6   142
```

For the purpose of this example we create a new column (`id_count`) that indicates how many times a given unit occurs and then add leading zeros to the `bm` and `bd` columns. Finally, we create a new string column that concatenates the information from all columns (excluding `rec_id`, `ent_id` and `id_count`) as presented below.

```
RLdata500[, id_count :=.N, ent_id]
RLdata500[, txt:=tolower(paste0(fname_c1,fname_c2,lname_c1,lname_c2,by,
                                sprintf("%02d", bm),sprintf("%02d", bd)))]
head(RLdata500[, .(rec_id, id_count, txt)])

#>   rec_id id_count          txt
#>   <int>   <int>         <char>
#> 1:     1       1 carstenmeier19490722
#> 2:     2       2  gerdbauer19680727
#> 3:     3       1 roberthartmann19300430
#> 4:     4       1 stefanwolff19570902
#> 5:     5       1 ralfkrueger19660113
#> 6:     6       1 juergenfranke19290704
```

As in the previous example, we use the `txt` column in the blocking function. This time, we set `ann = "hnsu"` to use the Hierarchical Navigable Small World (HNSW; [Malkov and Yashunin \(2018\)](#)) algorithm from the **RcppHNSW** package.

```
res_dedup <- blocking(x = RLdata500$txt,
                     ann = "hnsu",
                     verbose = 1)

#> ===== creating tokens =====
#> ===== starting search (hnsu, x, y: 500, 500, t: 429) =====
#> ===== creating graph =====
```

The results are as follows. This time the HNSW algorithm provided blocks varying from 2 to 17 units.

```
res_dedup

#> =====
#> Blocking based on the hnsu method.
#> Number of blocks: 133.
#> Number of columns used for blocking: 429.
#> Reduction ratio: 0.9916.
#> =====
#> Distribution of the size of the blocks:
#>  2  3  4  5  6  7  8  9 10 11 12 17
#> 46 35 23  8  6  6  2  3  1  1  1  1
```

Next, we create a long data table with information on blocks and units from the original dataset. We add the block information to the final dataset. We can check in how many blocks the same entities (`ent_id`) are observed. In our example, all the same entities are in the same blocks.

```
df_block_melted <- melt(res_dedup$result, id.vars = c("block", "dist"))
df_block_melted_rec_block <- unique(df_block_melted[, .(rec_id=value, block)])
RLdata500[df_block_melted_rec_block, on = "rec_id", block_id := i.block]
RLdata500[, .(uniq_blocks = uniqueN(block_id)), .(ent_id)][, .N, uniq_blocks]

#>    uniq_blocks      N
#>      <int> <int>
#> 1:         1    450
```

Additionally, we visualize the result based on the information whether a block contains matches or not.

```
df_for_density <- copy(df_block_melted[block %in% RLdata500$block_id])
df_for_density[, match:= block %in% RLdata500[id_count == 2]$block_id]

plot(density(df_for_density[match==FALSE]$dist),
     col = "blue", xlim = c(0, 0.8), main = "", xlab = "Distance")
lines(density(df_for_density[match==TRUE]$dist),
     col = "red", xlim = c(0, 0.8))
legend("topright", legend = c("Non-matches", "Matches"),
     col = c("blue", "red"), lty = 1, lwd = 2)
```

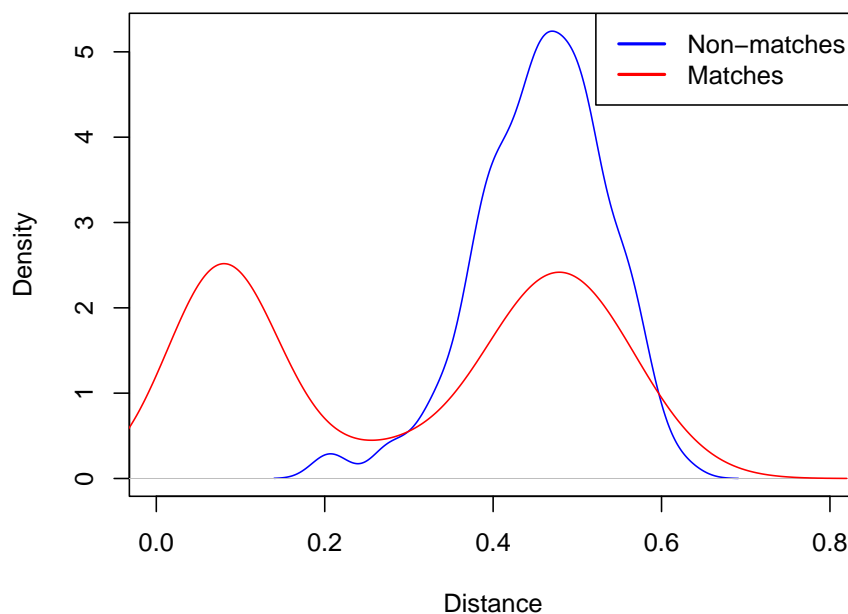


Figure 1: Distribution of distances between true matches and unmatches within blocks

Finally, we compare the evaluation metrics across all ANNs algorithms supported by the blocking function, i.e. NND, HNSW, Annoy (from the **RcppAnnoy** package), Locality-Sensitive Hashing (LSH, from the **mlpack** package), and k-Nearest Neighbours (kNN – denoted as "kd", from the **mlpack** package). We use the `rec_id` and `ent_id` columns from the `RLdata500` dataset to specify the true blocks and then calculate evaluation metrics for all algorithms.

We compare our package with the `klsh()` function from the **klsh** package, configured to create 10 blocks (denoted as `klsh_10`) and 100 blocks (denoted as `klsh_100`), respectively. In both settings, we use 20 random projections and 2-character shingles. The results are presented in Table 2.

```
set.seed(2025)
true_blocks <- RLdata500[, c("rec_id", "ent_id"), with = FALSE]
```

```

setnames(true_blocks, old = c("rec_id", "ent_id"), c("x", "block"))
eval_metrics <- list()
ann <- c("nnd", "hns", "annoy", "lsh", "kd")
for (algorithm in ann) {
  eval_metrics[[algorithm]] <- blocking(
    x = RLdata500$txt,
    ann = algorithm,
    true_blocks = true_blocks)$metrics
}

blocks_klsh_10 <- klsh::klsh(
  r.set = RLdata500[, c("fname_c1", "fname_c2", "lname_c1",
                        "lname_c2", "by", "bm", "bd")],
  p = 20,
  num.blocks = 10,
  k = 2)

klsh_10_metrics <- klsh::confusion.from.blocking(
  blocking = blocks_klsh_10,
  true_ids = RLdata500$ent_id)[-1]

klsh_10_metrics$f1_score <- with(klsh_10_metrics,
                                2*precision*recall/(precision + recall))

eval_metrics$klsh_10 <- unlist(klsh_10_metrics)

blocks_klsh_100 <- klsh::klsh(
  r.set = RLdata500[, c("fname_c1", "fname_c2", "lname_c1",
                        "lname_c2", "by", "bm", "bd")],
  p = 20,
  num.blocks = 100,
  k = 2)

klsh_100_metrics <- klsh::confusion.from.blocking(
  blocking = blocks_klsh_100,
  true_ids = RLdata500$ent_id)[-1]

klsh_100_metrics$f1_score <- with(klsh_100_metrics,
                                  2*precision*recall/(precision + recall))

eval_metrics$klsh_100 <- unlist(klsh_100_metrics)

round(do.call(rbind, eval_metrics) * 100, 2) |>
  kable(digits=2)

```

The results demonstrate a clear performance hierarchy among the ANNs algorithms implemented in the blocking package, with traditional tree-based methods (NND, HNSW, Annoy, and kNN) achieving perfect recall (100%) while maintaining excellent precision and F1 scores around 5-10%. Notably, these methods exhibit minimal FPR (0.73-0.80%) and maintain high specificity (99.20-99.27%), indicating their effectiveness in creating tight, accurate blocks.

In contrast, the LSH-based methods show more variable performance: the `mlpack` LSH implementation achieves 98% recall but suffers from higher FPR (3.74%) and importantly FNR (2%), while the `klsh` package results reveal a trade-off between block granularity and performance – `klsh_10` with only 10 blocks shows poor recall (84%), high FNR (10.13%) and FNR (16%), whereas `klsh_100` with 100 blocks recovers much of the performance

Table 2: Comparison of various approximate nearest neighbours algorithms implemented in the **blocking** and the **klsh** package for creation of blocks for deduplication

	recall	precision	fpr	fnr	accuracy	specificity	f1_score
nnd	100	5.17	0.74	0	99.26	99.26	9.83
hnswh	100	4.76	0.80	0	99.20	99.20	9.08
annoy	100	4.80	0.79	0	99.21	99.21	9.17
lsh	98	1.04	3.74	2	96.26	96.26	2.06
kd	100	5.19	0.73	0	99.27	99.27	9.87
klsh_10	84	0.33	10.13	16	89.87	89.87	0.66
klsh_100	90	3.72	0.94	10	99.06	99.06	7.14

(90% recall, 0.94% FPR but high FNR 10%). This indicate that the klsh, in particular these implementations of the LSH approach, miss large number of true matches.

These findings suggest that modern ANNs algorithms like NND, HNSW, and Annoy provide superior blocking performance for entity resolution tasks, offering both computational efficiency and high-quality results that minimize both missed matches and false linkages.

4 Summary

In this paper we have demonstrated the basic use cases of the **blocking** package. We believe that the software will be useful for researchers working in various fields where integration of multiple sources is an important aspect. This is certainly of interest in the field of official statistics where register-based statistics relies on high-quality linkage of administrative datasets or medical studies where assessment of health statistics relies on correct linkage of medical history and the treatment outcomes or mortality records.

Furthermore, users interested in integration with the **reclin2** package we refer to the documentation of the `pair_ann()` function and the vignette entitled "*Integration with existing packages*" which provides cases studies how the **blocking** package can be included in the existing record linkage / deduplication pipelines.

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We also have developed a python version of the package **BlockingPy** that is available through the PyPi It has the similar structure but offers more ANN algorithms (e.g. FAISS) or usage of embeddings. For more details see: Strojny, T., & Beręsewicz, M. (2025). *BlockingPy: approximate nearest neighbours for blocking of records for entity resolution*. arXiv preprint arXiv:2504.04266.

References

- M. Beręsewicz. Estimation of the number of foreigners in poland [szacunek liczby cudzoziemców w polsce]. Presentation at: Resident, But Who? – Measuring the Unmeasurable [Mieszkaniec, czyli kto? – zmierzyć niemierzalne], March 2025. URL https://dsp.stat.gov.pl/dsp2025/slides/sesja_3_problemy_pomiaru/2__beresewicz.pdf. March 24-25, 2025. [p1]
- O. Binette and R. C. Steorts. (almost) all of entity resolution. *Science Advances*, 8(12):eabi8021, 2022. doi: 10.1126/sciadv.abi8021. URL <https://www.science.org/doi/abs/10.1126/sciadv.abi8021>. [p1]

- G. Csardi and T. Nepusz. The igraph software package for complex network research. *InterJournal, Complex Systems*:1695, 2006. URL <https://igraph.org>. [p2]
- G. Csárdi, T. Nepusz, V. Traag, S. Horvát, F. Zanini, D. Noom, and K. Müller. *igraph: Network Analysis and Visualization in R*, 2025. URL <https://CRAN.R-project.org/package=igraph>. R package version 2.1.4. [p2]
- R. R. Curtin, M. Edel, O. Shrit, S. Agrawal, S. Basak, J. J. Balamuta, R. Birmingham, K. Dutt, D. Eddelbuettel, R. Garg, S. Jaiswal, A. Kaushik, S. Kim, A. Mukherjee, N. G. Sai, N. Sharma, Y. S. Parihar, R. Swain, and C. Sanderson. mlpack 4: a fast, header-only c++ machine learning library. *Journal of Open Source Software*, 8(82), 2023. doi: 10.21105/joss.05026. [p2]
- A. Dasylyva and A. Goussanou. Estimating the false negatives due to blocking in record linkage. *Survey Methodology*, 47(2):299–312, 2021. [p1]
- A. Dasylyva and A. Goussanou. On the consistent estimation of linkage errors without training data. *Japanese Journal of Statistics and Data Science*, 5(1):181–216, 2022. [p1]
- W. Dong, C. Moses, and K. Li. Efficient k-nearest neighbor graph construction for generic similarity measures. In *Proceedings of the 20th International Conference on World Wide Web, WWW '11*, page 577–586, New York, NY, USA, 2011. Association for Computing Machinery. ISBN 9781450306324. doi: 10.1145/1963405.1963487. URL <https://doi.org/10.1145/1963405.1963487>. [p5]
- D. Eddelbuettel. *RcppAnnoy: 'Rcpp' Bindings for 'Annoy', a Library for Approximate Nearest Neighbors*, 2024. URL <https://CRAN.R-project.org/package=RcppAnnoy>. R package version 0.0.22. [p2]
- T. Enamorado, B. Fifield, and K. Imai. Using a probabilistic model to assist merging of large-scale administrative records. *American Political Science Review*, 113(2):353–371, 2019. [p2]
- T. Enamorado, B. Fifield, and K. Imai. *fastLink: Fast Probabilistic Record Linkage with Missing Data*, 2023. URL <https://CRAN.R-project.org/package=fastLink>. R package version 0.6.1. [p2]
- I. P. Fellegi and A. B. Sunter. A theory for record linkage. *Journal of the American statistical association*, 64(328):1183–1210, 1969. [p1]
- J. P. Howard, II. Phonetic spelling algorithm implementations for R. *Journal of Statistical Software*, 95(8):1–21, 2020. doi: 10.18637/jss.v095.i08. [p1, 2]
- J. P. Howard, II. *phonics: Phonetic Spelling Algorithms in R*, 2021. URL <https://jameshoward.us/phonics-in-r/>. R package version 1.3.10. [p2]
- J. Johndrow, K. Lum, and D. Dunson. Theoretical limits of microclustering for record linkage. *Biometrika*, 105(2):431–446, 2018. [p2]
- T. Kalinowski and D. Falbel. *ragnar: Retrieval-Augmented Generation (RAG) Workflows*, 2025. URL <https://CRAN.R-project.org/package=ragnar>. R package version 0.2.0. [p2]
- Y. A. Malkov and D. A. Yashunin. Efficient and robust approximate nearest neighbor search using hierarchical navigable small world graphs. *IEEE transactions on pattern analysis and machine intelligence*, 42(4):824–836, 2018. [p9]
- J. Melville. *RcppHNSW: 'Rcpp' Bindings for 'hnsplib', a Library for Approximate Nearest Neighbors*, 2024a. URL <https://CRAN.R-project.org/package=RcppHNSW>. R package version 0.6.0. [p2]
- J. Melville. *rnndescent: Nearest Neighbor Descent Method for Approximate Nearest Neighbors*, 2024b. URL <https://CRAN.R-project.org/package=rnndescent>. R package version 0.1.6. [p2]

- T. Mikolov, K. Chen, G. Corrado, and J. Dean. Efficient estimation of word representations in vector space. *arXiv preprint arXiv:1301.3781*, 2013. [p1]
- L. A. Mullen, K. Benoit, O. Keyes, D. Selivanov, and J. Arnold. Fast, consistent tokenization of natural language text. *Journal of Open Source Software*, 3:655, 2018. doi: 10.21105/joss.00655. URL <https://doi.org/10.21105/joss.00655>. [p2]
- G. Papadakis, D. Skoutas, E. Thanos, and T. Palpanas. Blocking and filtering techniques for entity resolution: A survey. *ACM Comput. Surv.*, 53(2), Mar. 2020. ISSN 0360-0300. doi: 10.1145/3377455. URL <https://doi.org/10.1145/3377455>. [p1]
- M. Sariyar and A. Borg. The RecordLinkage Package: Detecting Errors in Data. *The R Journal*, 2(2):61–67, 2010. doi: 10.32614/RJ-2010-017. URL <https://doi.org/10.32614/RJ-2010-017>. [p2]
- M. Sariyar and A. Borg. *RecordLinkage: Record Linkage Functions for Linking and Deduplicating Data Sets*, 2025. URL <https://CRAN.R-project.org/package=RecordLinkage>. R package version 0.4-12.5. [p2]
- D. Selivanov, M. Bickel, and Q. Wang. *text2vec: Modern Text Mining Framework for R*, 2023. URL <https://CRAN.R-project.org/package=text2vec>. R package version 0.6.4. [p2]
- Y. Singh Parihar, R. Curtin, D. Eddelbuettel, and J. Balamuta. *mlpack: ‘Rcpp’ Integration for the ‘mlpack’ Library*, 2025. URL <https://CRAN.R-project.org/package=mlpack>. R package version 4.6.2. [p2]
- R. Steorts. *klsh: Blocking for Record Linkage*, 2020. URL <https://CRAN.R-project.org/package=klsh>. R package version 0.1.0. [p2]
- R. C. Steorts, S. L. Ventura, M. Sadinle, and S. E. Fienberg. A comparison of blocking methods for record linkage. In J. Domingo-Ferrer, editor, *Privacy in Statistical Databases*, pages 253–268, Cham, 2014. Springer International Publishing. ISBN 978-3-319-11257-2. [p1]
- D. J. van der Laan. reclin2: a toolkit for record linkage and deduplication. *R Journal*, 14(2), 2022. [p2]
- J. van der Laan. *reclin2: Record Linkage Toolkit*, 2024. URL <https://CRAN.R-project.org/package=reclin2>. R package version 0.5.0. [p2]
- M. van der Loo. The stringdist package for approximate string matching. *The R Journal*, 6: 111–122, 2014. URL <https://CRAN.R-project.org/package=stringdist>. [p2]
- M. A. Wright. Mechanizing a large index. *The Computer Journal*, 3(2):76, 1960. [p1]

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