

Detection of Duplicates Among Non-structured Data From Different Data Sources

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1 Introduction

2 Databases

- *Registre des Entreprises du Québec* (REQ)
- Private Dataset

3 Similarity Between Two Entities

- Similarity Algorithm
- Machine Learning

4 Conclusion

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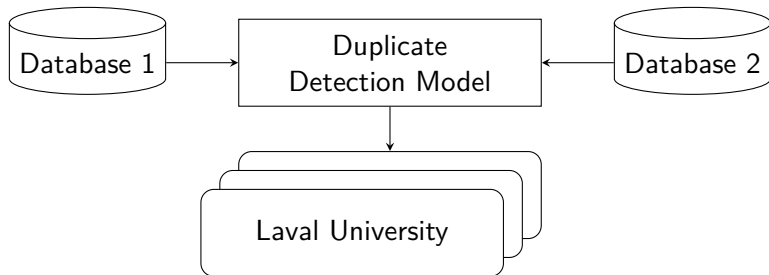
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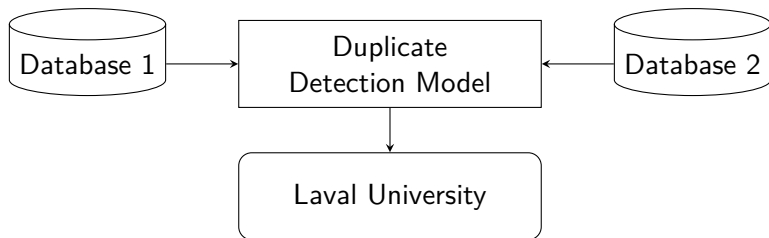
Example

David Beauchemin, the owner of "Beauchemin inc.", calls for insurance. Using minimal information, we want to retrieve as much as possible from an external source to ask him as less than the necessary number of questions.

How do we detect duplicate?



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Moreover, we consider only the top 1 document as the potential candidate.

To detect duplicate we need the following [Christen, 2012]

- databases (at least two) (section 2),
- a way to determine the similarity between two documents (section 3).

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- ~3.5 millions entries
[Registraire des entreprises du Québec, 2020]
 - ▶ Names
 - ▶ Address
 - ▶ Economic activities
 - ▶ Administrative informations

- 21,444 enterprises
 - ▶ Name
 - ▶ Address
 - ▶ Economic activity

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 - ▶ 1706 were annotated
 - ★ 1418 (*commercial risk, REQ entity*)
 - ★ 288 (*commercial risk, None*)
- We only use the name and the address.

We have used two versions of the name.

- 1 Normalize name (NN) : lowercase, whitespace and accent trimming.

Normalize Name

L'Université Laval \Rightarrow *l'universite laval*

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- 2 No stop words name (NSWN) : stop words trimming (i.e *le*, *la*, *de*) [Jurafsky and Martin, 2009].

No Stop Word Name

l'universite laval \Rightarrow *'universite laval*

We also use two versions of the address.

1 Complete Address Normalize (NA) : same as the name.

Complete Address Normalize

2325 rue de l'Université, Québec, QC, G1V 0A6



2325 rue de l'universite, quebec, qc, g1v 0a6

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- 2 Address components (AC) : parsed and grouped by address components [Yassine et al., 2020].

Address components

Civic Number	2325	Unit Number	∅
Street Name	rue de l'universite,	Postal Code	g1v 0a6
Orientation	∅		

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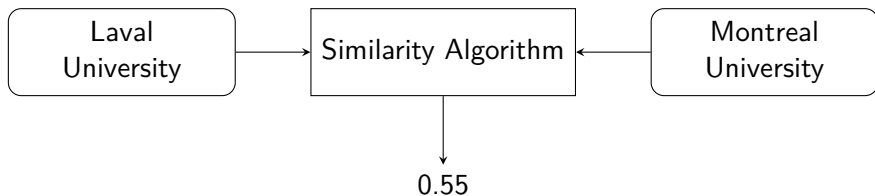
2 Databases

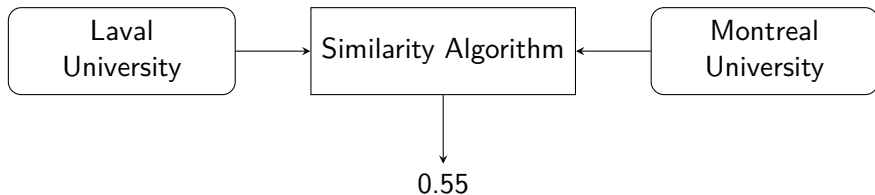
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Their similarity ranks the documents, and we select the best one as the duplicate candidate.

Similarities algorithms are one that measures the resemblance between two string base on the distance between their tokens.

10 different algorithms were used.

Jaccard Similarity

$$\text{Jaccard}(A, B) = \begin{cases} 0 & \text{if } |A \cap B| = 0 \text{ or } |A \cup B| = 0 \\ \frac{|A \cap B|}{|A \cup B|} & \text{otherwise} \end{cases}$$

Example

Jaccard(Laval University, Montreal University)



$$\frac{|\{\text{University}\}|}{|\{\text{University, Montreal, Laval}\}|} = \frac{1}{3} = \mathbf{0,333}$$

String to String (StoS)

$$\text{StoS}(A, B) = \begin{cases} 1 & \text{if } A_i = B_j \ \forall i, j \\ 0 & \text{otherwise} \end{cases}$$

Example

$\text{StoS}(\text{Laval University, Montreal University}) \Rightarrow 0$

$\text{StoS}(\text{Laval University, Laval University}) \Rightarrow 1$

Jaro-Winkler

$$\text{Jaro-Winkler}(A, B) = \text{Jaro}(A, B) + \frac{\min(P, 4)}{10} \times (1 - \text{Jaro}(A, B))$$

Example

$$\begin{aligned} &\text{Jaro-Winkler}(\text{David}, \text{Daniel}) = \\ &\text{Jaro}(\text{David}, \text{Daniel}) + \frac{2}{10} \times (1 - \text{Jaro}(\text{David}, \text{Daniel})) \\ &\quad \Downarrow \\ &0.7 + \frac{2}{10} \times 0.7 = 0.84 \end{aligned}$$

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- Give good results

	(%)	StoS	Jaro	Jaro-Winkler	Jaccard
NN	Accuracy	41.47	63.40	63.47	65.73
NSWN	Accuracy	44.15	64.46	65.23	66.50

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1. Positive examples only.

Name Interesting Results¹

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- The prefix similarity used by Jaro-Winkler improved results (more when using NSWN).

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	(%)	StoS	Jaro	Jaro-Winkler	CSS
CAN	Accuracy	0.00	48.03	48.10	45.91
AC	Accuracy	13.19	51.83	51.83	52.19

- StoS give poor results using the normalized address due to the unomalized standard of writing (e.g., "qc" VS "(quebec)" and order of components).

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- CSS gets the best results (14% below the previous best results using Jaccard).

2. Positive examples only.

Since 16% (270) of the pair (*commercial risk*, *REQ entity*) are missing a address, the results are under-evaluated. For example, the CSS accuracy without those pairs is at 62.74% near 10% higher.

Those missing addresses are due to the confidentiality policy of the REQ [Registraire des entreprises du Québec, 2017].

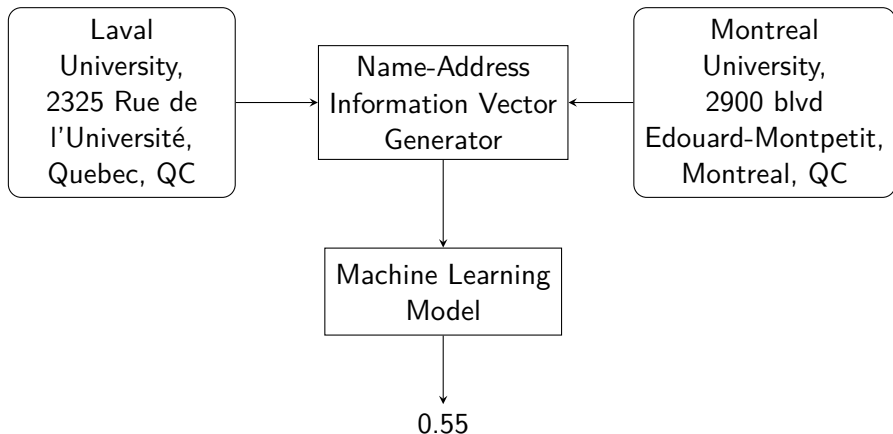
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- Using the NSWN or the AC helps improve the results over the normalized name or address.
- The missing addresses pull down the results.
- To use positive and negative examples, we need to use a decision function. Such as a similarity threshold, were similarity below the threshold are rejected (the results are not shown).

Machine Learning Similarity Algorithm



We used the previous similarity algorithm to generate an information vector between two entities using the NSWN and the CA.

Example of an information vector

StoS	Levenshtein	Jaro-Winkler	LCSP	Jaccard	Cosinus	-
0.00	0.15	0.25	0.35	0.15	0.15	-
StoS	Levenshtein	Jaro	LCSP	Jaccard	Cosinus	CSS
0.00	0.16	0.55	0.15	0.45	0.37	0.48

- 1 Logistic regression
- 2 Random Forest
- 3 Multilayer Perceptron

Why Machine Learning?

- Allow us to use the name and the address simultaneously
- Generalization capability

- 1 Data preprocessing
- 2 Hyperparameters grid search
- 3 Model training
- 4 Evaluation of the trained model for the duplicate detection task

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- We fit a standard scaler on the training dataset. With that standard scaler, we applied a transformation over all the vectors (train and test).

- A grid search for the logistic regression (C and tolerance) and the random forest (number of estimators).
- A random search for the multilayer perceptron (number of layers and neurons and the tolerance).
- Cross-validation approach using a 5-folds.

After the grid search, we retrain using the best parameters.

We evaluate our three trained models against the best configuration, Jaccard using the name, but reevaluated with the validation dataset (20% of the 1706 annotated examples).

We evaluated the algorithm with positives and negatives examples (for recall and precision). The decision function is a similarity threshold where a similarity below a numerical threshold (e.g., 0.7) is rejected.

We aim to maximize the recall since our objective is to detect the more duplicate as possible since we can, later on, validate the duplicate manually.

(%)	Logistic Regression	Random Forest	Multilayer perceptron	Jaccard
Precision	89,77	81,06	87,55	81,78
Recall	66,67	73,54	79,73	72,51
Accuracy	64,91	62,87	73,10	62,87

- The random forest and the multilayer perceptron achieve better recall than Jaccard. The best being the perceptron with near 80% recall.

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- The random forest and the multilayer perceptron achieve better recall than Jaccard. The best being the perceptron with near 80% recall.
- The logistic regression achieves the lowest result even if the Jaccard similarity is used in the generation of the information vector.

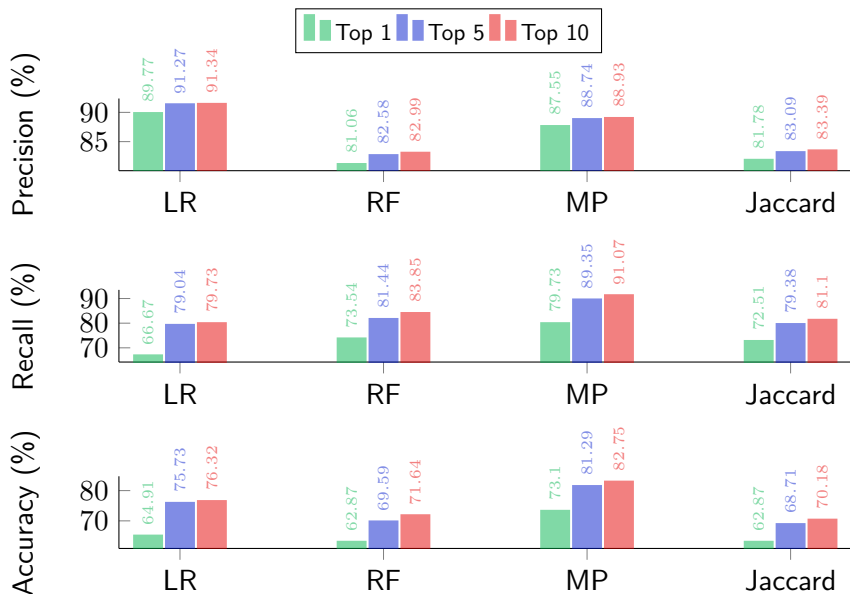
Commercial Risk	Entity
construction alain cloutier inc. 1030 rue de l'ardoise sherbrooke j1c 0j6	construction steve arbourd inc. 2-1822 rue notre-dame, l'ancienne-lorette, g2e 3c7

The following error was only generated with the logistic regression model. The algorithm matched the two with a similarity of 0.99934, even if the annotated duplicate appear with the same name and a slightly different address (similarity of 0.998).

The previous error highlights a problem of our approach ; so far, we have tried to match with **the** most similar, and the generated similarity are close to each other, making it restrictive to use only the best similarity.

Since our approach aims to prefill the information of an insurance application, we can return more than one and use a human validation to select the best one from N possibilities.

We consider a matching is good when the pair (*commercial risk*, *REQ entity*) is included in the N most similar.



- Using a top N approach greatly improved the results.
- Using $N = 10$, we can achieve a near max recall at 91% with the multilayer perceptron (max of 93% with the indexing).

(second)	Logistic Regression	Random Forest	Multilayer Perceptron	Jaccard
Time	1,32	1,74	1,34	0,25

- The used of name and address simultaneously with a machine learning algorithm improved the results.

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- Using a top N approach helps achieve better results when N is greater than 1.
- Inference times (of machine learning models) are similar to using only a similarity algorithm.

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- We have shown that using a similarity algorithm can achieve good results.
- Uses of machine learning algorithm (such as multilayer perceptron) can achieve greater results.
- Using a N most similar approach, where N is greater than one, help improved the results, achieving almost the max recall value.



- Word embeddings [Mikolov et al., 2013, Pennington et al., 2014, Wu et al., 2017, Foxcroft et al., 2019, Singh et al., 2019]
- Siamese Network [Godbole et al., 2018, Imtiaz et al., 2020]
- Uses of spatial data [Sehgal et al., 2006]
- Removal of more specific stop words using a TF-IDF approach [Sammut and Webb, 2010]

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- Luc Lamontagne for his mentorship.

-  Christen, P. (2012).
Data matching : concepts and techniques for record linkage, entity resolution, and duplicate detection.
Springer Science & Business Media.
-  Foxcroft, J., d'Alessandro, A., and Antonie, L. (2019).
Name2vec : Personal names embeddings.
In *Advances in Artificial Intelligence*, pages 505–510.
-  Godbole, A., Dalmia, A., and Sahu, S. K. (2018).
Siamese neural networks with random forest for detecting duplicate question pairs.
-  Imtiaz, Z., Umer, M., Ahmad, M., Ullah, S., Choi, G. S., and Mehmood, A. (2020).
Duplicate Questions Pair Detection Using Siamese MaLSTM.
IEEE Access, 8 :21932–21942.

-  Jurafsky, D. and Martin, J. H. (2009).
Part-of-speech tagging.
In Speech and Language Processing (2nd Edition), chapter 8.
Prentice-Hall, Inc.
-  Mikolov, T., Chen, K., Corrado, G., and Dean, J. (2013).
Efficient Estimation of Word Representations in Vector Space.
-  Pennington, J., Socher, R., and Manning, C. (2014).
GloVe : Global vectors for word representation.
In Proceedings of the Conference on Empirical Methods in Natural Language Processing, pages 1532–1543.
-  Registraire des entreprises du Québec (2017).
Banque de données publique sur les entreprises au Québec - Guide d'intégration fonctionnelle.
Québec.

-  Registraire des entreprises du Québec (2020).
Le registre et son contenu.
http://www.registreentreprises.gouv.qc.ca/fr/a_propos/registre/.
-  Sammut, C. and Webb, G. I., editors (2010).
TF-IDF, pages 986–987.
Springer US.
-  Sehgal, V., Getoor, L., and Viechnicki, P. D. (2006).
Entity resolution in geospatial data integration.
In Proceedings of the 14th Annual ACM International Symposium on Advances in Geographic Information Systems, page 83–90.
Association for Computing Machinery.
-  Singh, L., Singh, S., Arora, S., and Borar, S. (2019).
One embedding to do them all.

-  Wu, L., Fisch, A., Chopra, S., Adams, K., Bordes, A., and Weston, J. (2017).
Starspace : Embed all the things !
-  Yassine, M., Beauchemin, D., Laviolette, F., and Lamontagne, L. (2020).
Leveraging subword embeddings for multinational address parsing.