Improved Evaluation Framework for Complex Plagiarism Detection

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Plagiarism Detection

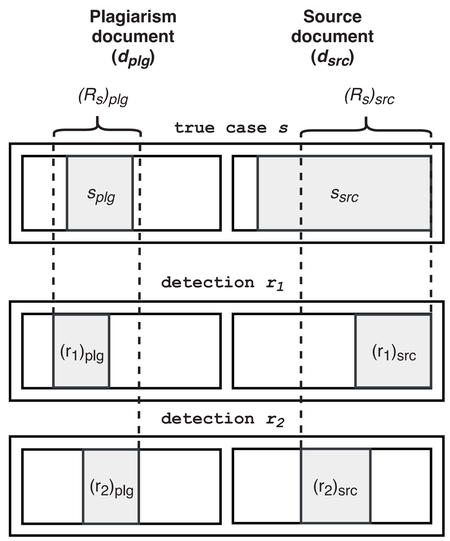
- Plagiarism is a major issue in science and education. Complex plagiarism is **hard to detect** ⇒ important to track improvement of methods.
- Plagiarism and source parts of complex PD **datasets are often imbalanced** as a result of paraphrazing or summarization.
- The main PD evaluation framework is Plagdet. We study its performance on PAN Summary datasets and show that it **fails to distinguish** good PD systems from bad ones under certain conditions.
- We propose **normalized** version of **Plagdet** which is resilient to dataset imbalance.

Dataset Imbalance Example

Dataset	Plagiarism (plg)	Source (src)
Train	626 ± 45	5109 ± 2431
Test-1	639 ± 40	3874 ± 1427
Test-2	627 ± 42	5318 ± 3310

The average plagiarism case **is much shorter** than the source case in PAN 2013 Summary datasets.

Text Alignment



- **Given two documents** d_{plg} and d_{src},
- **Detect all pairs of passages** $r \in R$, such that $r_{plg} \in d_{plg}$ is a "plagiariasm" of $r_{src} \in d_{src}$,
- **Calculate their intersection** with golden-set of true cases $s \in S$ as a quality measure.

normPlagdet: Proposed Evaluation Framework

- Plagdet framework consists of precision, recall, granularity and their weighted harmonic mean[a]:

$$prec(S,R) = \frac{1}{|R|}\sum_{r\in R}\frac{|\bigcup_{s\in S}(s\sqcap r)|}{|r|}, \quad rec(S,R) = \frac{1}{|S|}\sum_{s\in S}\frac{|\bigcup_{r\in R}(s\sqcap r)|}{|s|}, \quad gran(S,R) = \frac{1}{|S_R|}\sum_{s\in S_R}|R_s|,$$

$$plagdet(S,R) = \frac{F_\alpha(prec(S,R), rec(S,R))}{\log_2(1+gran(S,R))}.$$

- Let us rewrite recall using the notion of **single-case recall**:

$$rec(S,R) = \frac{1}{|S|}\sum_{s\in S} rec_{single}(s,R_s) = \frac{1}{|S|}\sum_{s\in S}\frac{|s_{plg}\cap(R_s)_{plg}| + |s_{src}\cap(R_s)_{src}|}{|s_{plg}| + |s_{src}|}, \tag{1}$$

where R_s is the union of all detections of a given case s.

- Then we apply normalization to the inner term in Eq. 1 to obtain **normalized single-case recall**:

$$nrec(S,R) = \frac{1}{|S|}\sum_{s\in S} nrec_{single}(s,R_s) = \frac{1}{|S|}\sum_{s\in S}\frac{\mathbf{w_{plg}}(|s_{plg}\cap(R_s)_{plg}|) + \mathbf{w_{src}}(|s_{src}\cap(R_s)_{src}|)}{\mathbf{w_{plg}}(|s_{plg}|) + \mathbf{w_{src}}(|s_{src}|)},$$

where $w_i(x) = (x-a_i)\frac{b_i-a_i}{|d_i|}$, $i \in \{plg, src\}$, and a_i / b_i is a minimum / maximum possible size of the case s intersecting all of its detections: $s_i \cap (R_s)_i$.

- Finally, we see that $prec(S,R) = rec(R,S)$ and therefore we define **normalized plagdet** as

$$normplagdet(S,R) = \frac{F_\alpha(nprec(S,R), nrec(S,R))}{\log_2(1+gran(S,R))}. \tag{2}$$

[a] Here we only consider *macro-averaged* precision and recall; the results hold for *micro-averaged* case as well, but they are harder to explain in a limited space. We provide implementation for both macro- and micro-averaged metrics, see link below.

Comparison of metrics

We constructed two adversarial models, **M1** and **M2**, that exploit dataset imbalance in their prediction to achieve high **plagdet** on PAN Summary datasets, but significantly lower **normalized plagdet**.

Dataset	Model	Year	Plagdet	Normplagdet
PAN 2013 Test-1	Sanchez-Perez et al.	2014	0.6703	0.7965
	Brlek et al.	2016	0.8180	0.8783
	Sanchez-Perez et al.	2018	**0.8841**	**0.9319**
	Adversarial M1	2018	0.8320	0.2614
	Adversarial M2	2018	0.4739	0.1700
PAN 2013 Test-2	Sanchez-Perez et al.	2014	0.5638	0.7470
	Brlek et al.	2016	0.7072	0.8107
	Sanchez-Perez et al.	2018	0.8125	**0.8859**
	Adversarial M1	2018	**0.8789**	0.2869
	Adversarial M2	2018	0.4848	0.1559

Lessons learned

- Plagdet, standard evaluation metric for PD, does not reflect the performance correctly and can be misused on datasets for manual plagiarism detection to achieve higher scores.
- Normalization of inner terms in single-case precision and recall prevents misusage of dataset imbalance on text alignment tasks.
- When introducing new dataset, the evaluation metric should be checked to match its properties.

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Our implementation is freely available at `https://github.com/AVBelyy/normplagdet`