

AUTHORSHIP ATTRIBUTION WITHIN DIFFERENT DARK WEB FORUMS

BY USING STATISTICAL ANALYSIS OF STRINGS



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//ABSTRACT

The popularity of the Dark Web increases year by year. This can have benign reasons such as companies which are trying to protect their communications from the eyes of their competitors. However, it can also have malicious reasons because the Dark Web offers anonymity to all its users and thus also to users with illegal intentions such as selling drugs, trading stolen credit cards or weapons. Due to the technology of Dark Web mechanisms like TOR, it is a difficult task for law enforcement groups to trace such users. The process of Authorship Attribution(AA) is used to identify an author of a set of different texts. Lots of research has been done in the field of AA, as well as the Dark Web but only a few researchers concentrated on a combination of both. Hence, this research focuses on whether AA can be used to overcome this difficulty mentioned above, or not. Therefore, in this project **AA is applied within a single and two different Dark Web forums (Silkroad 2 and The Hub)**. For that, a classification model is created that is based on a voting classifier that uses the result of multiple machine learning classifiers.

//INTERMEDIATE RESULTS

Feature	FP Rate	Precision	Classifier
Lexical	0.021	0.809	NBM
	0.026	0.783	SVM
	0.043	0.611	J48
	0.032	0.721	RF
	-	-	LMT
Time	0.095	0.123	NBM
	0.076	0.277	SVM
	0.031	0.716	J48
	0.023	0.795	RF
	0.031	0.716	LMT
Stylometric	0.065	0.488	NBM
	0.047	0.583	SVM
	0.055	0.503	J48
	0.040	0.640	RF
	0.040	0.637	LMT
Social	0.088	0.188	NBM
	0.087	0.286	SVM
	0.081	0.327	J48
	0.081	0.316	RF
	0.081	0.317	LMT

Feature	FP Rate	Precision	Classifier
Time & Stylometric	0.064	0.500	NBM
	0.039	0.653	SVM
	0.039	0.644	J48
	0.029	0.737	RF
	0.028	0.743	LMT
Time & Social	0.080	0.338	NBM
	0.064	0.414	SVM
	0.032	0.706	J48
	0.025	0.774	RF
	0.033	0.703	LMT
Social & Stylometric	0.062	0.488	NBM
	0.045	0.603	SVM
	0.052	0.538	J48
	0.037	0.673	RF
	0.037	0.661	LMT
Time, Social & Stylometric	0.055	0.513	NBM
	0.037	0.679	SVM
	0.036	0.676	J48
	0.027	0.757	RF
	0.027	0.759	LMT
	0.014	0.876	VOTING

NBM = NAIVEBAYESMULTINOMIAL
SVM = SUPPORT VECTOR MACHINE
RF = RANDOM FOREST
LMT = LOGISTIC-MODEL-TREES

All results were achieved by using WEKA with 500-600 posts per user and 10-fold-cross-validation

//CONCLUSION

Authorship attribution within a single and two different Dark Web forums is the focus of this research. A new classification model is created that is based on a voting classifier. It is feed with the result of three different classification processes which classifying each post based on different features. The NaiveBayesMultinomial (NBM) classifier was figured out as the best choice for analyzing the lexical features. Furthermore, the time features worked best in combination with a Random Forest (RF) classifier as well as the stylometric features did. However, the stylometric features achieved better results in combination with the social features when using this classifier. By applying this approach on posts from the Silkroad 2 forum, a precision of over 90% and a false positive rate of 1.1% was achieved. However, AA within different forums is not as straightforward as within a single forum. PGP-Keys instead of usernames are used to link the users between different forums. However, this research achieved a precision of 75% and an FP rate of 6.4% when classifying posts of authors of SR2 in The Hub.

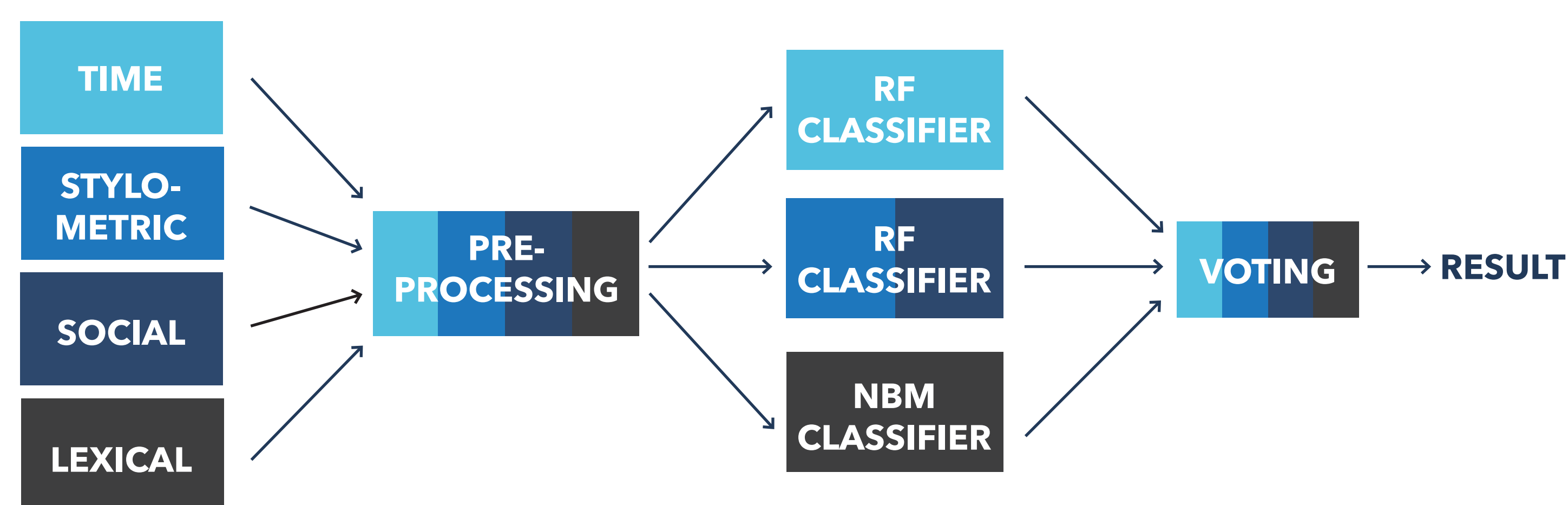
FINAL RESULT #1

AA WITHIN SR2 ONLY

FP RATE	PRECISION	CLASSIFIER
0.019	0.828	NBM
0.019	0.830	SVM
0.030	0.734	J48
0.030	0.746	RF
-	-	LMT
0.011	0.903	VOTING

*500-600 POSTS, 10-FOLD-CROSS-VALIDATION

//CLASSIFICATION MODELL



FINAL RESULT #2

AA WITHIN SR2 AND THE HUB

- » 200+ POSTS PER USER
- » SR2 FOR TRAINING
- » THE HUB FOR TESTING
- » VOTING APPROACH ONLY
- » **PRECISION OF: 0.746**
- » **FP RATE OF: 0.064**

//PREVIOUS RESEARCH

Author	Title	Year	Environment	Classifier	Features
Thanh Nghia Ho and Wee Keong Ng	Application of stylometry to darkweb forum user identification	2016	Dark Web (Forum)	Support Vector Machine (SVM)	Stylometric, character-bigrams and trigrams
M. Spitters et al.	Authorship analysis on dark marketplace forums	2015	Dark Web (Forum)	SVM	Time, stylometric, character n-grams
M. Ashcroft et al.	Multi-domain alias matching using machine learning	2016	Surface Web (Forum / Twitter)	Ada Boost, SVM, Naive Bayes	Emotion, stylometric, time
S. R. Pillay and T. Solorio	Authorship attribution of web forum posts	2010	Surface Web (Forum)	Bayes Net, Naive Bayes, C4.5	Statistical language models, stylometric features, clustering solutions
M. Sultana, P. Polash, and M. Gavrilova	Authorship recognition of tweets: A comparison between social behavior and linguistic profiles	2017	Surface Web (Twitter)	Own statistical calculation	Social behavior (SB) profiles, linguistic profiles (BOW, Style-Markers)

//FUTURE WORK

- » Reduce the false positive rate, improve the precision
- » Create an own data set
- » Use one classifier per author
- » Add other, new feature categories (E.g. text converted into gray-scale images)
- » Review existing features
- » Analyze the similarity of usernames within different forums