SPAMIA: Spam filtering by quantitative profiles

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Content

Spam

- an unsolicited email message
- is ussually send in a bulk to spread advert or viruses, or for phishing, scam, verification of email, ...

Existing solutions for spam filtering

Methods

- heuristic rules
- naive Bayes filtering
- text-mining methods

Open-source products

SpamAssassin

Bogofilter

DSPAM

...

Comercial products

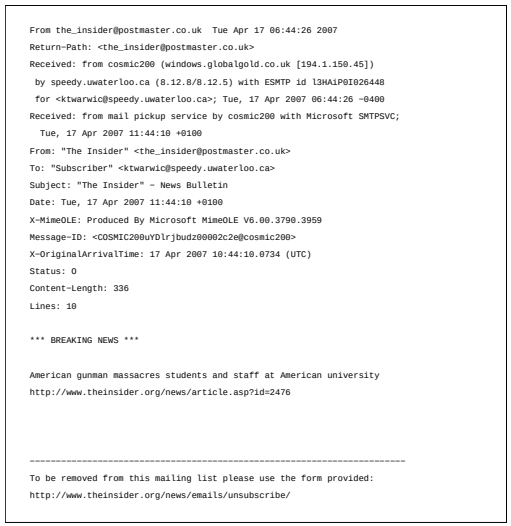
Disadvantages of existing solutions

- language dependence
- heuristic rules are fixed
- necessity to update these rules
- high vulnerability
- high computational costs

Quantitative profile approach

Quantitative profile approach

- an email is represented by an m-dimensional vector of numbers with m fixed in advance
- QPs serve as an input to a classification algorithm



```
From the_insider@postmaster.co.uk  Tue Apr 17 06:44:26 2007
Return-Path: <the_insider@postmaster.co.uk>
Received: from cosmic200 (windows.globalgold.co.uk [194.1.150.45])
 by speedy.uwaterloo.ca (8.12.8/8.12.5) with ESMTP id l3HAiP0I026448
 for <ktwarwic@speedy.uwaterloo.ca>; Tue, 17 Apr 2007 06:44:26 -0400
Received: from mail pickup service by cosmic200 with Microsoft SMTPSVC;
  Tue, 17 Apr 2007 11:44:10 +0100
From: "The Insider" <the_insider@postmaster.co.uk>
To: "Subscriber" <ktwarwic@speedy.uwaterloo.ca>
Subject: "The Insider" - News Bulletin
Date: Tue, 17 Apr 2007 11:44:10 +0100
X-MimeOLE: Produced By Microsoft MimeOLE V6.00.3790.3959
Message-ID: <COSMIC200uYDlrjbudz00002c2e@cosmic200>
X-OriginalArrivalTime: 17 Apr 2007 10:44:10.0734 (UTC)
Status: O
Content-Length: 336
Lines: 10

*** BREAKING NEWS ***

American gunman massacres students and staff at American university
http://www.theinsider.org/news/article.asp?id=2476



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$$QP = (qp_1, qp_2, \ldots, qp_m)$$

Basic quantitative profiles

Binary profile: distances between occurences of special character/characters (only first $k = 100$ occurences for each email)

- LP line: lengths of lines
- WP word: lengths of words
- BRP brackets: distances between brackets
- ...

Histogram binary profile:

- HWP: histogram of lengths of words
- HBRP: histogram of distances between brackets
- ...

Basic quantitative profiles

Character profile: the number of occurrences of the characters

- CP: characters from $\mathcal{A}$ (ASCII character set)

Grouped character profile: the number of occurrences of the groups of characters

- CPG9: numbers, spaces, brackets, operators, separators, upper/lower-case letters, forbidden characters, other
- CPG11: as CPG9, separately ! a $

d-gram grouped character profile:

- 2CPG11: pairs of groups of characters
- 3CPG11: triples of groups of characters
- ...

Basic quantitative profiles

Moving window profile: CPGs for each parts of email

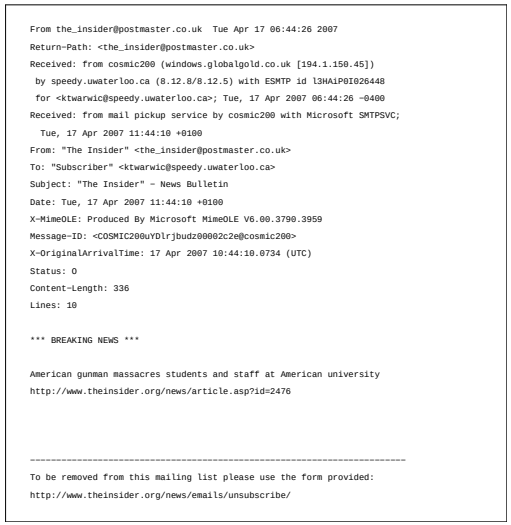
- MWPCPG11

Size profile:

- size of email
- sizes of selected headers
- sizes of parts of email according to content-type
- (optional) CPG of headers and parts

- SP
- SPCPG11

Graphical representation of line and character profile



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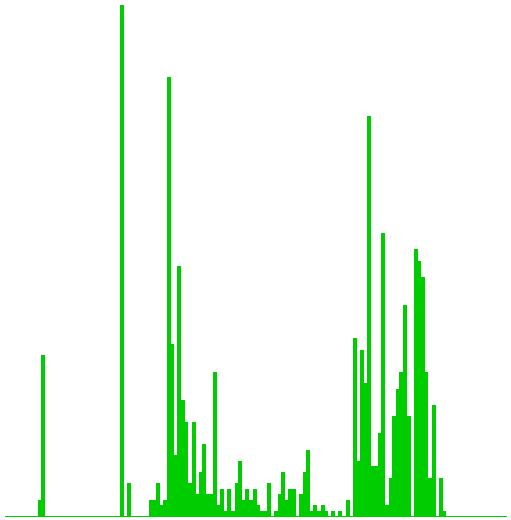
(a) Email

(b) Line profile



(c) Character profile

Results

Test corpuses

TREC 2007 corpus of 75 419 emails (spam 66.6%)

- train: 50 000 (68.3%)
- test: 25 419 (63.1%)

CEAS 2008 corpus of 137 705 emails (spam 80.3%)

- train: 90 000 (81.2%)
- test: 47 705 (77.9%)

Performance measures and classification algorithm

Performance measures

- false negative rate *fnr* (the ratio of misclassified spam) at fixed low values of false positive rate *fpr* (the ratio of misclassified ham)
- the receiver operating characteristic (*ROC*) curve, i.e. the graph of the true positive rate vs. the false positive rate, obtained as functions of the decision threshold

Classification algorithm

- Random Forest classifier

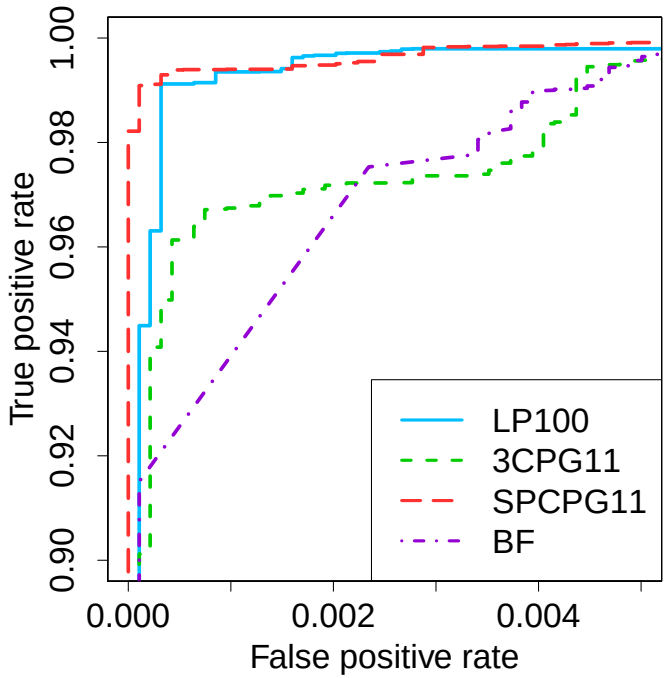
Performance of quantitative profiles

fnr (%) at fixed $fpr = 0.1\%$

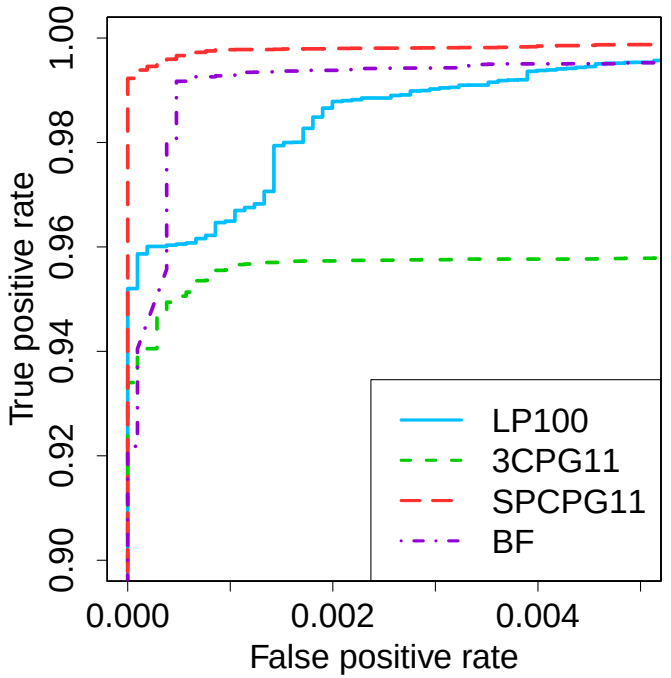
filter	TREC 2007	CEAS 2008
LP	0.65	3.46
WP	0.52	8.89
BRP	6.22	4.88
CP	14.61	4.98
3CPG11	3.26	4.42
MWPCPG11	17.26	5.45
SP	4.33	0.51
SPCPG11	0.60	0.22
SpamAssassin-RF	66.06	92.23
Bogofilter	7.98	0.71

Performance of quantitative profiles

ROC curves



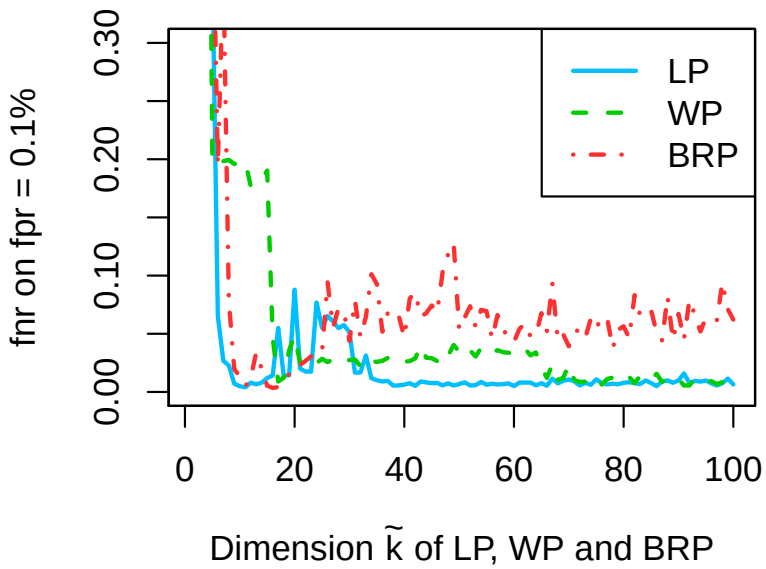
(a) TREC 2007



(b) CEAS 2008

Dimension of binary profiles

Dependence of BPs performance on its dimension



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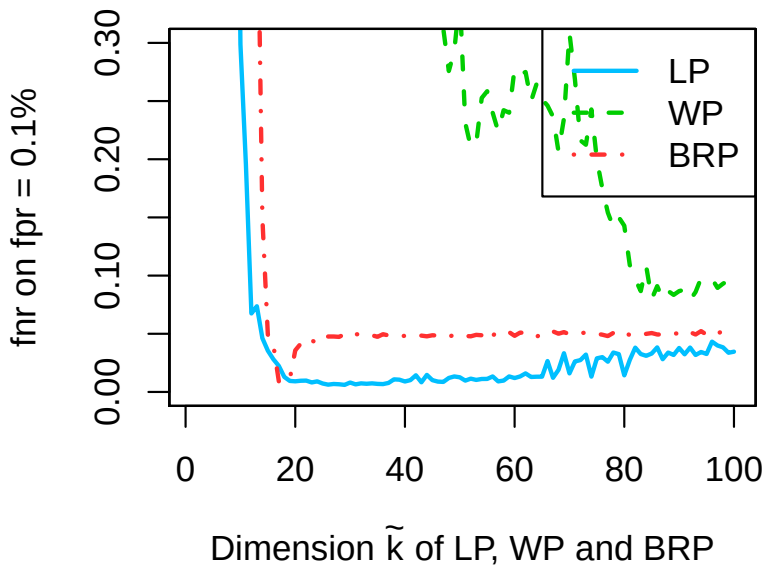
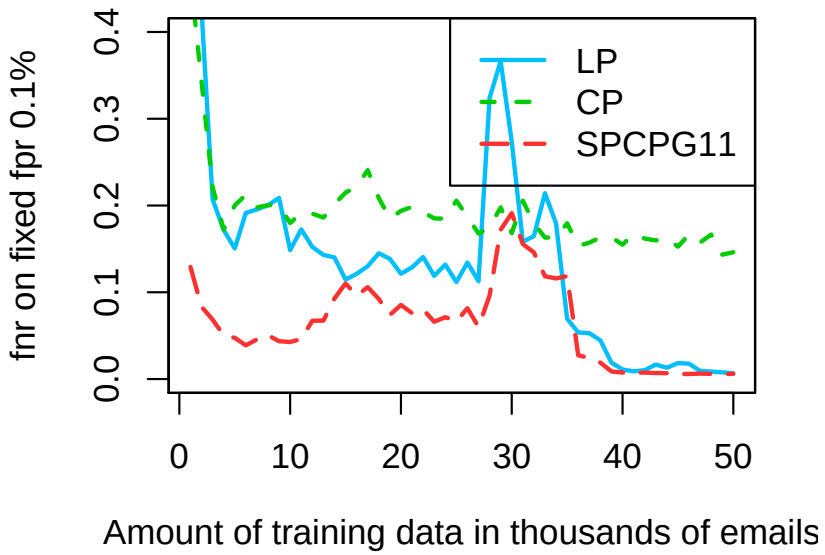


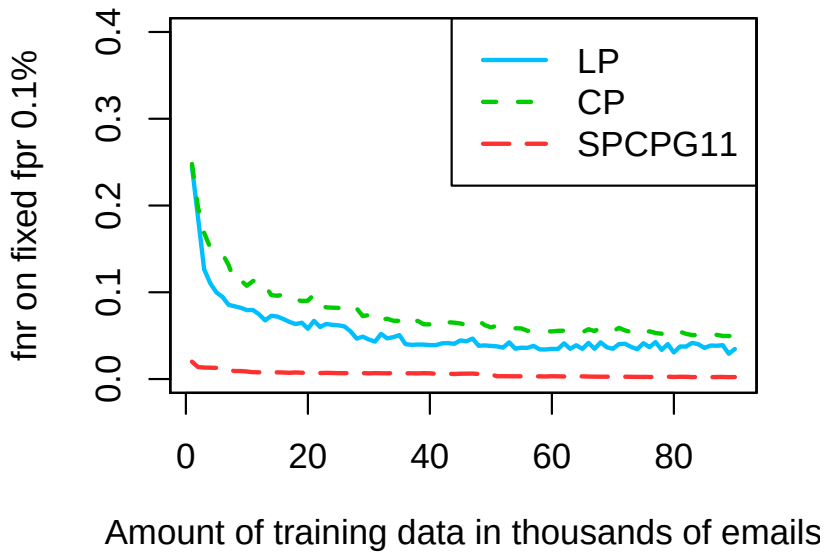
(b) CEAS 2008

Learning curves

Dependence of QPs performance on the size of training set



(a) TREC 2007



(b) CEAS 2008

Conclusions

Conclusions

- quantitative profiles based Random Forest classifiers attain very good performance, at least comparable or better to that of Bogofilter and much better than optimized SpamAssassin
- the resulting filters are:
  - highly scalable
  - easy to parallelize (thanks to RF)
  - independent of language
  - easy to combine with other filters (thanks to QPs)

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Thank you for your attention.