Standardized Spam Filter Evaluation

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Why Standardized Evaluation?

To answer questions!

- Is spam filtering a viable approach?
- What are the risks, costs, and benefits of filter use?
- Which spam filter should I use?
- How can I make a better spam filter?

What's the alternative?

- Testimonials
- Uncontrolled, unrepeatable, statistically bogus tests
- Warm, fuzzy feelings

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There's no Perfect Test

But a standardized test should

- Model real filter usage as closely as possible
- Evaluate the filter on criteria that reflect its effectiveness for its intended purpose
- Eliminate uncontrolled differences
- Be repeatable
- Yield statistically meaningful results

Future tests will

- Challenge assumptions in the current test

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TREC – Text Retrieval Conference

Sponsored by, held at

NIST – National Institute for Standards & Technology

http://trec.nist.gov

Goals

To increase the availability of appropriate evaluation techniques for use by industry and academia, including the deployment of new evaluation techniques more applicable to current systems.

Format

Participants do experiments in one or more *tracks*

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TREC Timetable

February 21, 2005 (*now*!)

Answer call for participation (SPAM track)

Winter/Spring, 2005

Mailing list discussion, finalize experimental setup

Summer 2005

Prepare and submit filters for evaluation

November 15-18, 2005

TREC Conference, results presented, methods discussed

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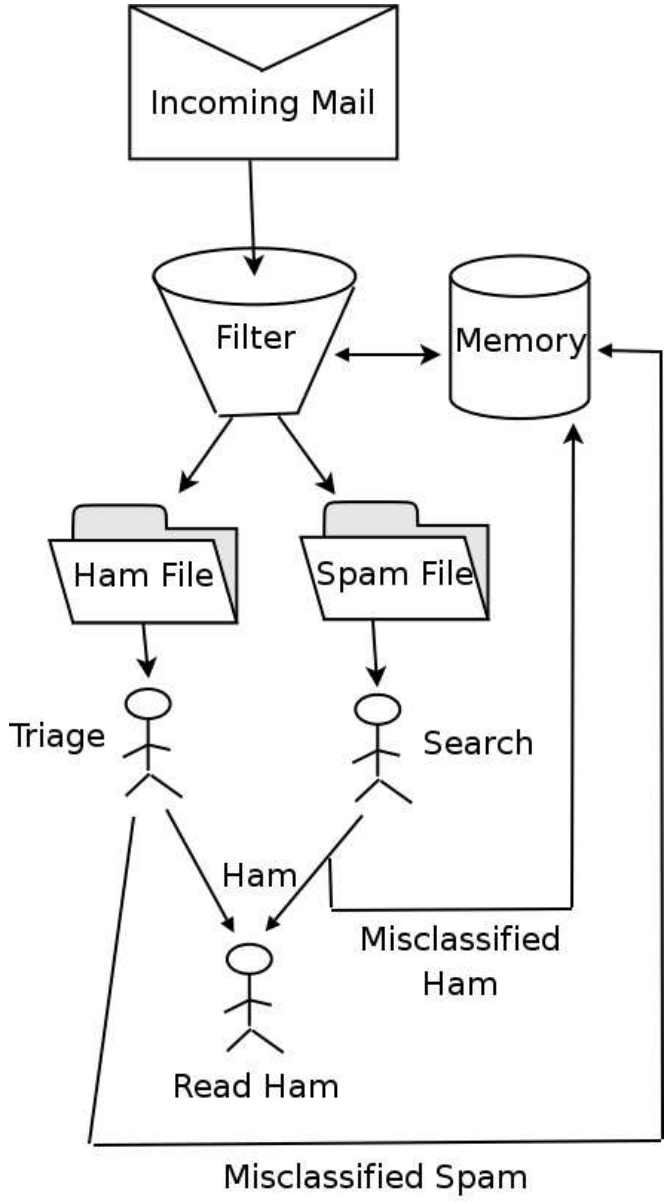
Spam Filter Usage



- Filter Classifies Email
- Human addressee
  - Triage on ham File
  - Reads ham
  - Occasionally searches for misclassified ham
  - Report misclassified email to filter

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Simulating Email Stream

- Identify user
- Secure user's permission (tacit or explicit)
  - this is the hard part
    - User's sensitivities
    - Sender's sensitivities
    - 3rd Parties sensitivities
    - Privacy legislation & ethics
- Capture email exactly as delivered

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Spam Filter Evaluation

- Simulate (replay) incoming email stream
  - *single* recipient (for now)
  - chronological order
  - full email message with *original* headers
- Simulate *idealized* user's behaviour
  - reports *all* misclassifications *immediately*
    - spam in ham file (spam misclassification, false negative)
    - ham in spam file (ham misclassification, false positive)
- Capture filter results
- Analyze captured results

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Simulating *Idealized* User

- Capture
  - Filter result for each message (ham/spam)
  - User's reports of misclassified ham or spam
- But Real Users are not *Ideal*
  - err and are inconsistent
  - slow and haphazard in reporting misclassification
- Real User involved in pilot evaluation
  - vets disagreements between user and filter
- Gold Standard ham/spam judgement

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Standardized Filter Interface

Filter must implement exactly 3 commands

initialize

All steps necessary to install the software on a clean system and to prepare to classify a user's email.

classify *filename*

read *filename* which contains exactly 1 email message

write one line of output:

classification score auxiliary_file

train *judgement filename classification auxiliary_file*

take note of gold-standard *judgement*

filename, classification, auxiliary_file from prior **classify**

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Filter Test Jig

Input

User email stream, 1 message per file

Index file, 1 line per message, chronological order:

judgement filename genre

Filter, as 3 commands: *initialize, classify, train*

Output

Raw Result File, 1 line per message:

file=*filename* **judge=***judgement* **class=***classification*
genre=*genre*

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Test Jig Implementation

initialize

for each *judgement, filename, genre* in index

classify *filename* > *classification, score, auxiliary_file*

train *judgement filename classification auxiliary_file*

output *judgement, filename, classification, score, genre*

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Analysis – Contingency Table

		Gold Standard Judgement: ham	Gold Standard Judgement: spam
Filter Classification	ham	a	b
	spam	c	d

a: ham (correctly classified) [true negative]
b: spam misclassification [false negative]
c: ham misclassification [false positive]
d: spam (correctly classified) [true negative]

c/(a+c): ham misclassification rate
b/(b+d): spam misclassification rate
(c+d)/(a+b+c+d): overall misclassification rate
(a+d)/(a+b+c+d): accuracy *(equivalent to overall misc. rate)*

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Ham vs. Spam Tradeoff

Most filters compute *spamminess*

if *spamminess* > *threshold* then classify as spam

else classify as ham

threshold value is arbitrary

higher threshold =

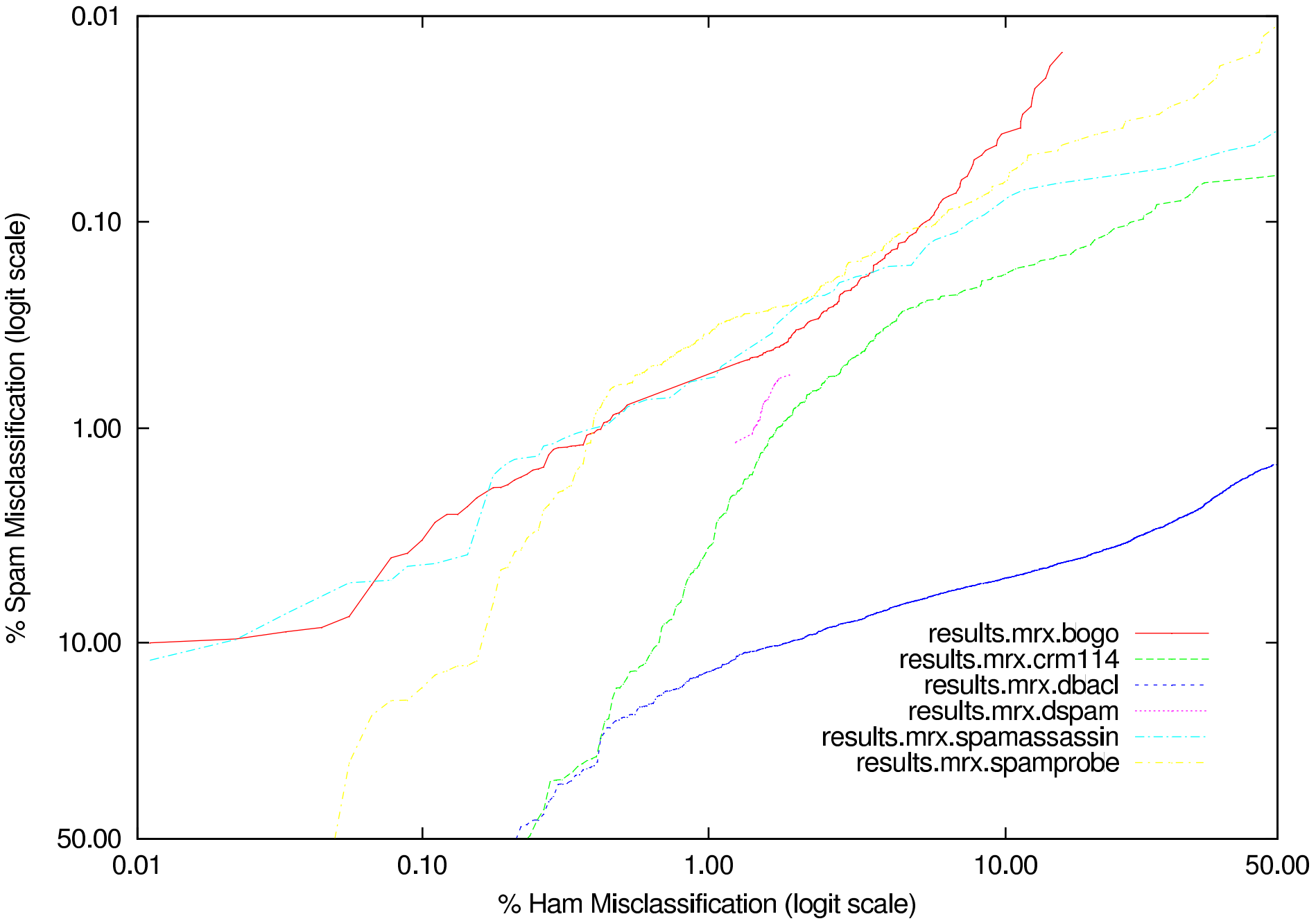
fewer ham misclassifications

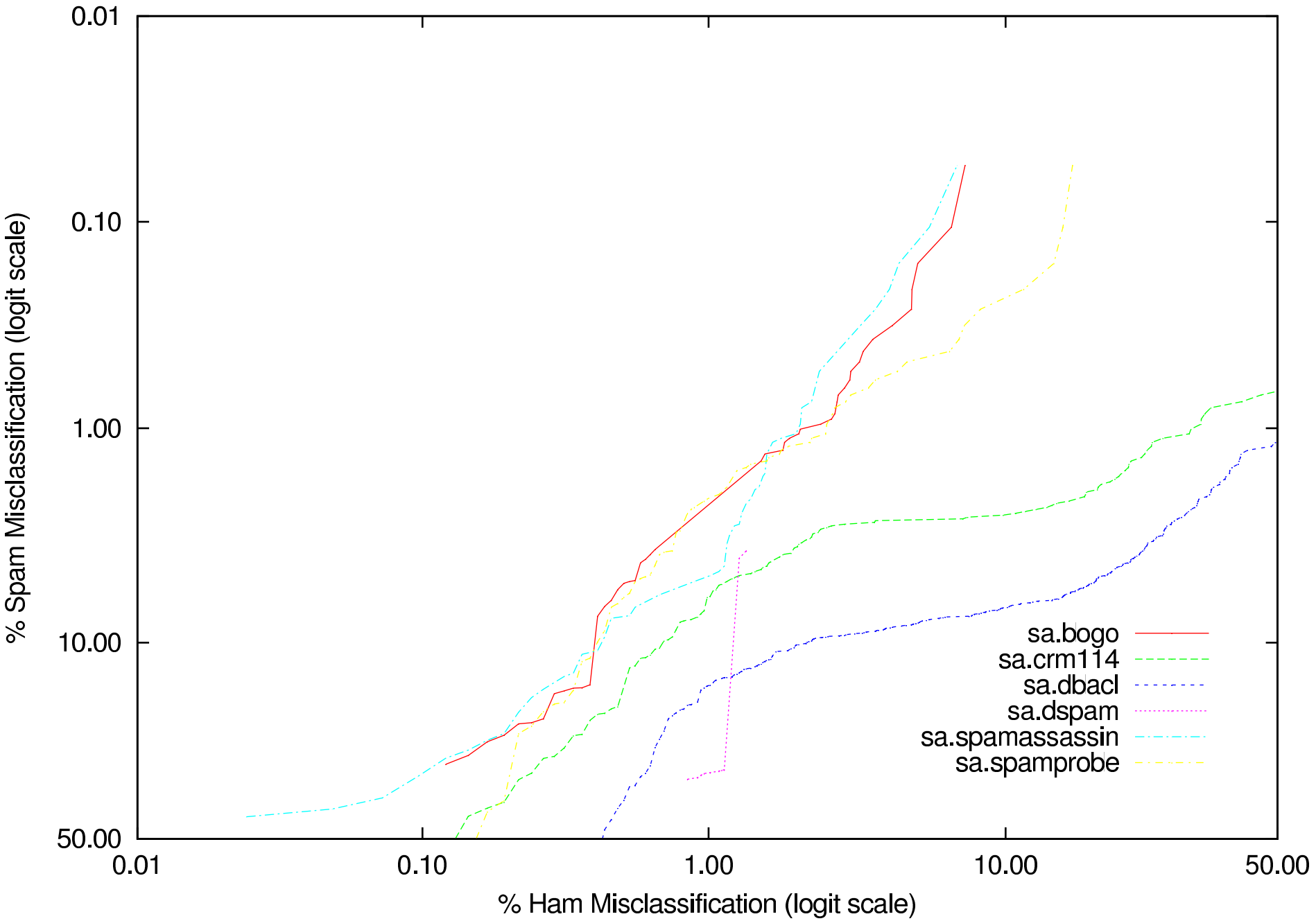
more spam misclassifications

ROC (Receiver Operating Characteristic) Curve

vary *threshold*, plot ham misc. vs. spam misc.

Area under curve approaches 1 (perfect filter)


0.01
0.10
1.00
10.00
50.00
% Spam Misclassification (logit scale)
0.01
0.10
1.00
10.00
50.00
% Ham Misclassification (logit scale)
results.mrx.bogo
results.mrx.crm114
results.mrx.dbacl
results.mrx.dspam
results.mrx.spamassassin
results.mrx.spamprobe


0.01
0.10
1.00
10.00
50.00
% Spam Misclassification (logit scale)
0.01
0.10
1.00
10.00
50.00
% Ham Misclassification (logit scale)
sa.bogo
sa.crm114
sa.dbacl
sa.dspam
sa.spamassassin
sa.spamprobe

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Some Numbers

	Private Corpus (Mr. X)				Public Corpus (Spamassassin)			
Filters	**1-ROCA%**	**ham%**	**spam%**	**misc%**	**1-ROCA%**	**ham%**	**spam%**	**misc%**
bogo	0.04	0.07	6.48	5.30	0.19	0.19	23.93	7.61
spamassassin	0.06	0.06	5.88	4.81	0.18	0.70	6.10	2.39
spamprobe	0.10	0.41	0.85	0.77	0.28	0.80	3.13	1.52
crm	0.40	2.24	0.68	1.00	1.14	1.81	4.03	2.50
dspam	0.91	1.39	0.94	1.02	3.42	1.01	32.79	10.94
dbacl	2.41	0.65	17.31	14.25	2.95	1.71	11.35	4.72
Corpus Size		9038	40048	49086		4149	1885	6034

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Analysis - Learning Curve

Misclassification as a function of messages learned

Define p = Prob(misclassification after n messages)

Logistic Regression

Assume $$\log\left(\frac{p}{1-p}\right) = an+b$$

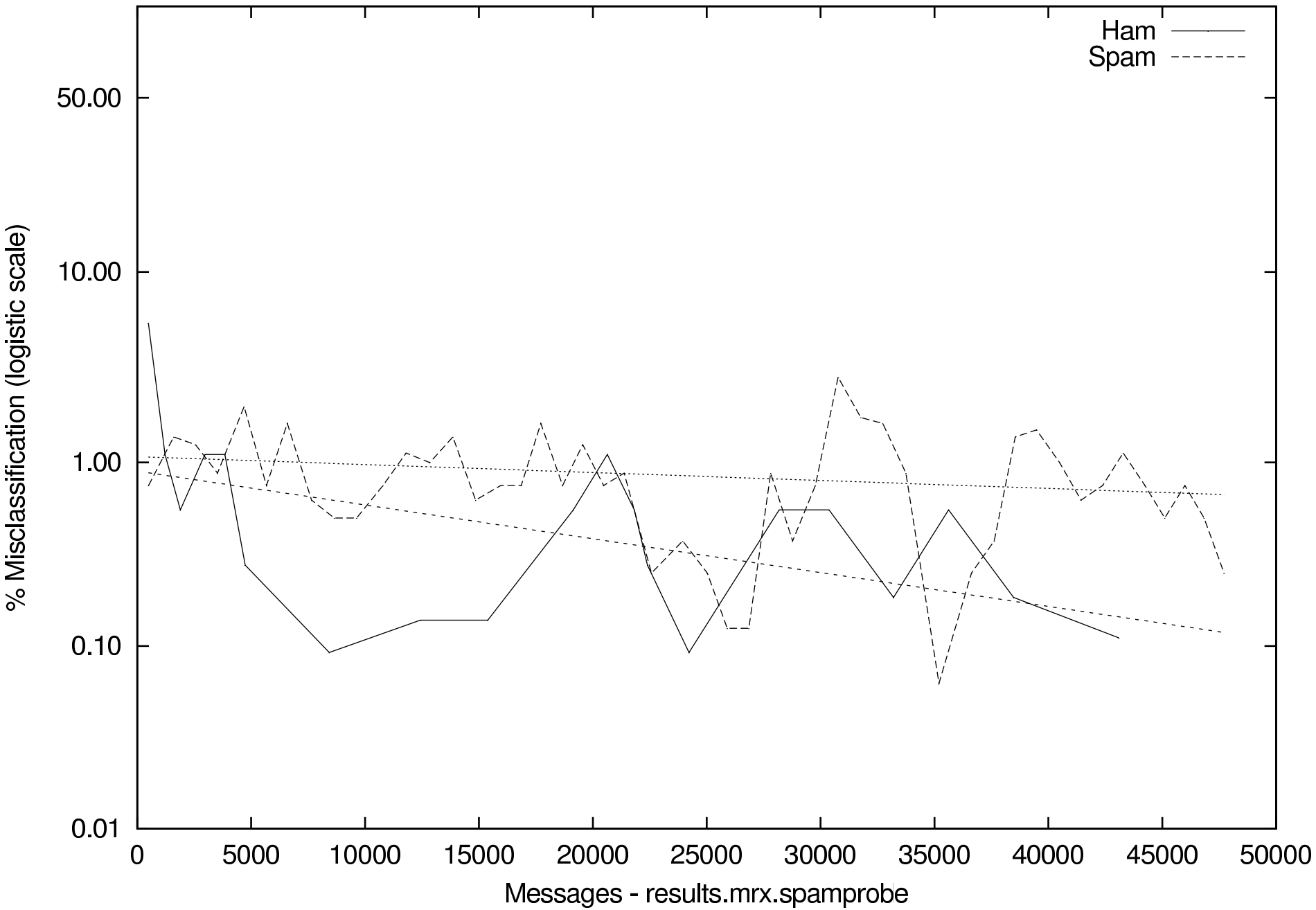
Compute a, b that best fit data:

maximum likelihood estimate

Piecewise Estimate

Divide $1..n$ into 50 interval and compute p

Coalesce adjacent intervals so when $p = 0$


Ham
Spam
50.00
10.00
1.00
0.10
0.01
% Misclassification (logistic scale)
0
5000
10000
15000
20000
25000
30000
35000
40000
45000
50000
Messages - results.mrx.spamprobe

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Genre Classification

- Not all types of ham are equal!
  - Some more likely misclassified
    - higher likelihood of ending up in spam filter
  - Some more likely missed if filtered
    - can be retrieved from spam file
  - Some more valuable
    - consequences of non-receipt vary dramatically
- Overall downside risk depends on all these factors
- Spam can similarly be classified

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Date: Thu, 13 Jan 2005 22:18:07 +0000 (GMT)
To: gvcormac@uwaterloo.ca


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Main Contact Information **Booking Reference: KUDM2M**

Name:	**Doctor Gordon V Cormack**
Email:	**gvcormac@uwaterloo.ca**
Phone 1:	**1-905-6272457**
Credit Card#:	**xxxx-xxxx-xxxx-5359**

Electronic Ticketing confirmed.
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Flight Itinerary

Flight	From	To	Stops	Duration	Aircraft	Fare Type
AC364	**Toronto (YYZ)** Thu 20-Jan 2005 16:10 - Terminal 2	**Boston (BOS)** Thu 20-Jan 2005 17:42 - Terminal C	0	1hr32	319	Tango
AC359	**Boston (BOS)** Sat 22-Jan 2005 12:35 - Terminal C	**Toronto (YYZ)** Sat 22-Jan 2005 14:21 - Terminal 2	0	1hr46	CRJ	Tango

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Subject: International e-Conference on Computer Science 2005 (IeCCS 2005)
From: "Ï”Ï . ÎˆÎµÏŒÎ´Ï‰Ï Î¿Ï, Î£Î¯Î¼Î¿Ï, - Dr. Theodore Simos" <tsimos@mail.ariadne-t.gr>
Date: Thu, 13 Jan 2005 04:37:10 +0200
To: secretary@ieccs.net
CC: tsimos@mail.ariadne-t.gr

Dear Colleagues

This year we organise the International e-Conference on Computer Science 2005 (IeCCS 2005) from 12 to 17 May 2005.

Please circulate the following announcement, call for papers, sessions and minisymposia and leaflet to your colleagues.

If you want leaflets and posters for IeCCS 2005, please send your request to secretary@ieccs.net

Sincerely yours

Professor Dr. T.E. Simos
Chair and Organiser IeCCS 2005

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Ham Genre Examples

Personal email from a regular correspondent

Personal email from first-time correspondent

Advertising (acceptable to recipient)

Email delivery failure notices

Mailing lists (formal and informal)

News clipping services

Internet transactions

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Spam Genre Examples

Advertising

Scams

Demographic-targetted

Backscatter

Virus

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Further Resources

TREC - **trec.nist.gov**

- Call for participation
- Description of tracks
- Past proceedings

Spam Track – **plg.uwaterloo.ca/~gvcormac/spam**

- Preliminary guidelines
- Test jig, analysis tools, sample filters
  - Linux prototype only – will evolve

Methodology - **plg.uwaterloo.ca/~gvcormac/spamcormack**