Automated Verbatim Coding: State of the Art and Future Perspectives

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Coding verbatim responses is a bit like doing the dishes after hosting a dinner party: a somewhat tedious and time-consuming experience (...). At least, that was the case before dishwashers became commonplace.

*[Tim Macer, Quirk's Marketing Research Review, **16**(7), 2002.]*

Outline

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1. Introduction
2. VCS: an automated Verbatim Coding System
3. VCS: Effectiveness Tests
   - Effectiveness at the individual level
   - Effectiveness at the aggregate level
4. VCS: Efficiency Tests
5. The future

About myself ...

- A senior research scientist at ISTI-CNR, and a former professor of the Department for Pure and Applied Mathematics of the University of Padova, Italy, ...
- ... and the leader of the Automatic Verbatim Coding Project at ISTI-CNR;
- CNR: the Italian National Council of Research, i.e., the largest government-owned research institution in Italy, devoted to basic and applied research in all fields of science;
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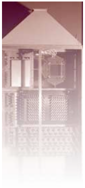

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... and my research interests

- Since 1998: "information retrieval", "automatic learning", "computational linguistics", with an emphasis to applications in automatic text coding (e.g., coding newswire reports, coding medical discharge reports, coding patent applications, etc.)
- Since 2003, I have also worked in (automatically) coding verbatim text returned to open-ended questions (e.g., from social surveys, or from customer satisfaction surveys)
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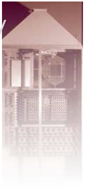

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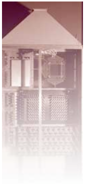

VCS (cont'd)

- Originally commissioned by Egg plc, the largest purely online bank in the world (now part of Citigroup);
- Developed in collaboration with Archimede Informatica, a sw company in Pisa, Italy;
- Deployed in July 2006, now fully operational and managing all of Egg's customer satisfaction verbatim data (≈ 20,000 questionnaires per month, plus huge backlogs).

VCS: the underlying philosophy

- VCS is an adaptive system for automatically coding verbatim responses under any user-specified codeframe (aka “codebook”); given such a codeframe, VCS automatically generates an automatic coding system for this codeframe.
- Actually, the basic unit along which VCS works is the code: given a codeframe consisting of several codes, for each such code VCS automatically generates a binary classifier, i.e., a system that decides whether a given verbatim should or should not be attributed the code.

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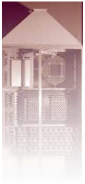
VCS: the underlying philosophy (cont'd)

- VCS is based on a learning metaphor: the system learns from manually coded data the characteristics a new verbatim should have in order to be attributed the code; the manually coded data need to include positive examples of the code and negative examples of the code;
- Providing manually coded examples of the code to the system is by no means different than providing a child with (positive and negative) examples of, say, what a tiger is, in order to teach him to recognize tigers.



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This is a tiger!

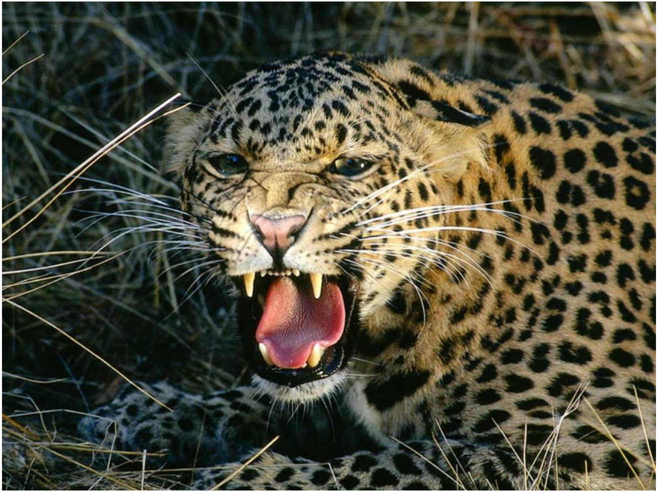
This is another tiger!

This is yet another tiger!

Also a tiger!

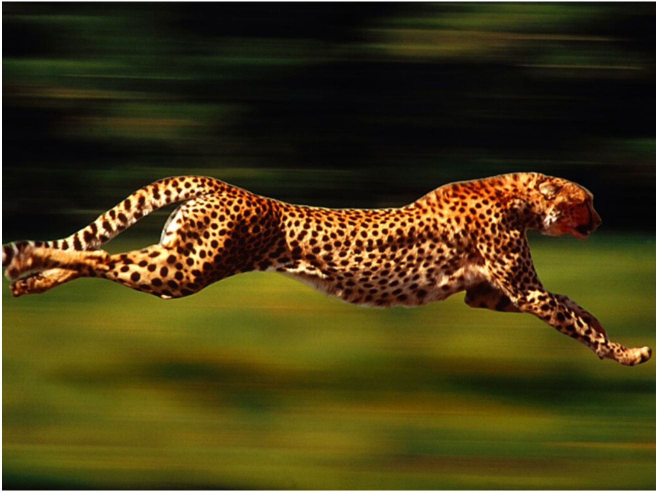
This is a NOT a tiger!

NOT a tiger either!

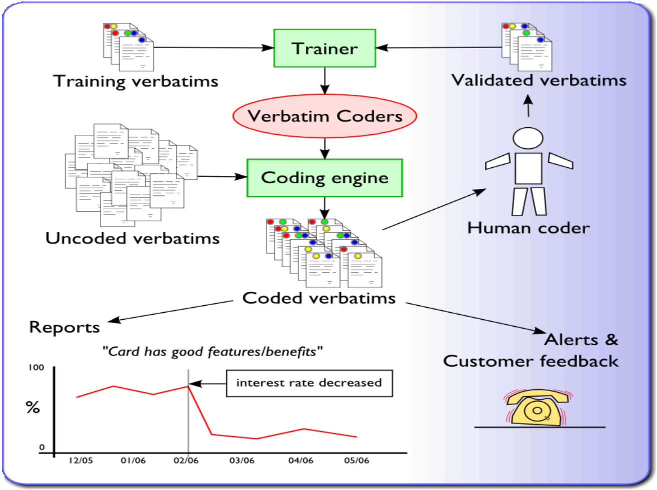


Absolutely NOT a tiger!

Is this a tiger?



The VCS information flow



Advantages of learning metaphor

- No need for expert to write coding rules in arcane language; the system only needs user-coded examples for training;
- Easy update to
  - shifted meaning of existing code
  - revised codeframe
  - brand new codeframe or brand new survey

  since the system only needs user-coded examples for training that reflect the new situation;
- Does not use any specialized resource (e.g, thesauri);
- Pretty good effectiveness at the "individual level", excellent effectiveness at the "aggregate level", excellent learning and coding speed.

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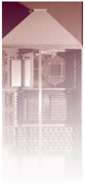

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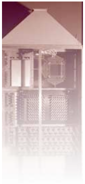

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- By accuracy (or effectiveness) of a coding system we refer to the frequency with which the coding decisions of the system are expected to agree with the coding decisions that an expert coder (the "gold standard") would make.
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Effectiveness: individual or aggregate?

- Effectiveness may be measured at two different levels:
  - At the individual level: the perfect system is the one which, for a code C, assigns C to the verbatim exactly when the expert coder would have assigned C.
  - At the aggregate level: the perfect system is the one which, for a code C, assigns x% of the verbatims to C exactly when the expert coder would have assigned x% of the verbatims to C.
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Precision and Recall

- Effectiveness testing requires an effectiveness measure to be defined and agreed upon. The one we adopt, called F_1, relies on the following two notions:
- For a given code C, precision (denoted π) measures the ability of the system to avoid "overcoding", i.e., attributing C when it should not be attributed; that is, the ability of the system to avoid "false positives" (aka "errors of commission", or "Type I errors") for code C.
- For a given code C, recall (denoted ρ) measures the ability of the system to avoid "undercoding", i.e, failing to attribute C when it should instead be attributed; that is, the ability of the system to avoid "false negatives" (aka "errors of omission", or "Type II errors") for code C.

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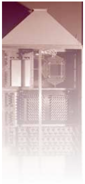

The F_1 measure

- In a given experiment, precision and recall are computed from a contingency table:

Code C		coder says	
		YES	**NO**
system says	**YES**	TP	FP
	NO	FN	TN

- Precision is defined as $\pi = \frac{TP}{TP + FP}$
- Recall is defined as $\rho = \frac{TP}{TP + FN}$
- The effectiveness measure we adopt is F_1, the "harmonic mean" of precision and recall, defined as

$$F_1 = \frac{2 \cdot \pi \cdot \rho}{\pi + \rho} = \frac{2 \cdot TP}{(2 \cdot TP) + FP + FN}$$

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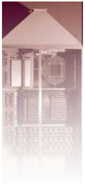

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Testing effectiveness on an example dataset

Example: 100 verbatims, codeframe consisting of two codes C_i and C_j:

Code C_i		coder says YES	coder says NO
system says	**YES**	15	7
	NO	8	70

Code C_j		coder says YES	coder says NO
system says	**YES**	22	13
	NO	5	60

$$\pi = \frac{15}{15+7} = \frac{15}{22} = .682$$
$$\rho = \frac{15}{15+8} = \frac{15}{23} = .652$$
$$F_1 = \frac{2 \cdot .682 \cdot .652}{.682 + .652} = .667$$

$$\pi_j = \frac{22}{22+13} = \frac{22}{35} = .629$$
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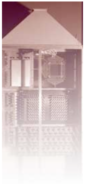

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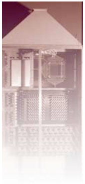

Computing effectiveness wrt an entire codeframe

- Precision, recall and F_1 can also be computed relative to an entire codeframe by using a "combined" contingency table

Codes C_i and C_j		coder says YES	coder says NO
system says	YES	$15+22$	$7+13$
	NO	$8+5$	$70+60$

$$\pi^{\mu} = \frac{(15+22)}{(15+22)+(7+13)} = \frac{37}{57} = .649$$

$$\rho^{\mu} = \frac{(15+22)}{(15+22)+(8+5)} = \frac{37}{50} = .740$$

$$F_1^{\mu} = \frac{2 \cdot .649 \cdot .740}{.649 + .740} = .692$$

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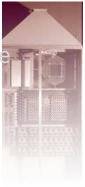
Why is F_1 a good measure of effectiveness?

- $F_1 = 0$ for the "pervert system" $(TP = TN = 0)$ and $F_1 = 1$ for the "perfect system" $(FN = FP = 0)$.
- It partially rewards partial success: i.e., if the true codes of a verbatim are c_1, c_2, c_3, c_4, attributing c_1, c_2, c_3 is rewarded more than attributing c_1 only.
- It is not easy to game: it has very low values for "trivial" coding systems (e.g. the "trivial rejector" has $F_1 = 0$, the "trivial acceptor" has $F_1 = \frac{TP+FN}{TP+FP+FN+TN}$, which is usually low).
- It rewards systems that balance precision and recall.
- It is symmetric; i.e., the agreement between system and coder is the same as the agreement between coder and system.
- It is (thus) an "industry standard" in the field of text coding.



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- It partially rewards partial success: i.e., if the true codes of a verbatim are c_1, c_2, c_3, c_4, attributing c_1, c_2, c_3 is rewarded more than attributing c_1 only.
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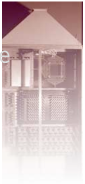

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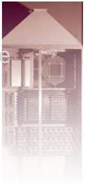

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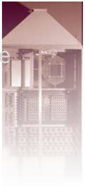

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Real tests: the Language Logic data & the Egg data

DS	$\|Tr\|$	$\|Te\|$	$\|C\|$	ATC	$\|D\|$	AVL	LR	F_1^μ
LL-A	201	65	18	21.00	61	1.35	.344	.92
LL-B	501	10299	34	26.65	151	1.65	.176	.90
LL-C	201	425	20	10.05	60	1.61	.168	.89
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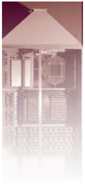

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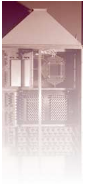

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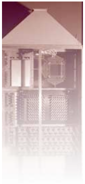

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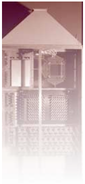

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- Is $F_1 = .92$ exactly 8% worse than I would get from my coders? No, since your coders won't get you $F_1 = 1$.
- How good a given F_1 value on the part of VCS is can only be measured in an intercoder agreement study, i.e., wrt the value of F_1 that two human coders would achieve wrt each other on the same dataset. For codes
  1. "Coke" for question "What is your favourite soft drink?"
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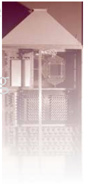

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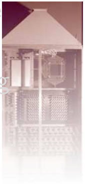

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- We have experimentally observed that the F_1 of VCS tends to increase with
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  - the degree of "linguistic regularity" (LR) in the training verbatims;
  - how uncontroversial the code is, which can be measured by intercoder agreement. On the Egg datasets VCS was roughly 85% as good as expert human coders.

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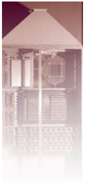

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Outline

The PD measure

- We measure effectiveness at the aggregate level by PD, the discrepancy between the true percentage and the predicted percentage of respondents belonging to code C; the perfect system has $PD = 0$.
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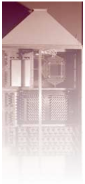

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Effectiveness at the aggregate level

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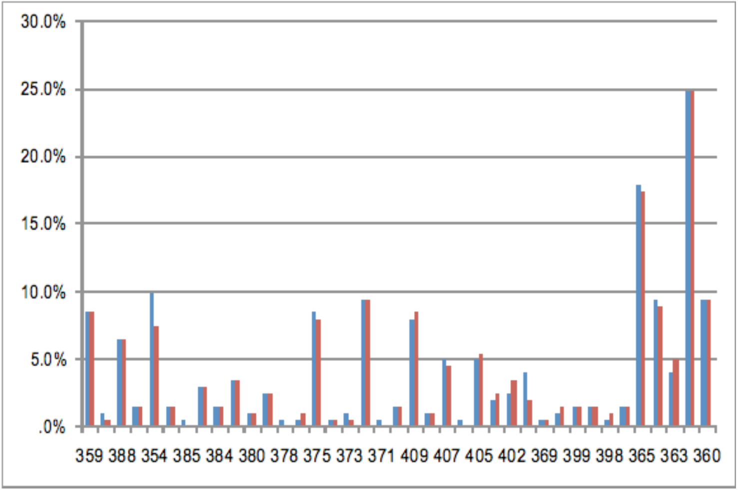
LL-B	34	.90	.006	.048
LL-C	20	.89	.007	.074
LL-D	27	.85	.008	.056
LL-E	39	.84	.004	.025
LL-F	57	.82	.007	.048
LL-G	104	.80	.005	.052
LL-H	86	.79	.007	.057
LL-I	69	.78	.008	.052
LL-L	65	.75	.010	.096
Egg-A	14	.63		
Egg-B	20	.60		

Example: the LL-E dataset



Why is VCS so good at the aggregate level?

- VCS excels at the aggregate level because it explicitly tries to maximize F_1 ...
  - ... and to maximize F_1 you need to balance precision and recall ...
  - ... and to balance precision and recall you must balance false positives and false negatives ...
  - ... and if $FP = FN$, then $PD = 0$!
- Contrary to VCS, human coders often have high PD wrt each other, since it is typically the case than one coder may be consistently more liberal (or conservative) than the other.
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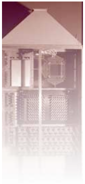

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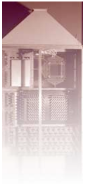

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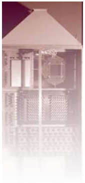

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Outline

1. Introduction
2. VCS: an automated Verbatim Coding System
3. VCS: Effectiveness Tests
   - Effectiveness at the individual level
   - Effectiveness at the aggregate level
4. VCS: Efficiency Tests
5. The future

- There are two sides to efficiency in VCS:
  - Training-time efficiency: how fast can the automated classifiers for a given codeframe be generated from a given set of training verbatims?
  - Coding-time efficiency: how fast can the classifiers generated for a given codeframe code new, yet uncoded data?
- Our tests on Egg data indicate that, for a 20-code codeframe
  - The classifiers can be generated from 1000 training examples in approximately 2 minutes altogether;
  - 100,000 verbatims can be coded automatically in approximately 8 minutes.
- In our tests on Language Logic data both training and coding were, on average, approximately 7.6 times faster than on Egg data (due to higher "linguistic regularity").
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  - Sophisticated control panel, for answering the questions
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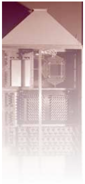

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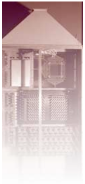

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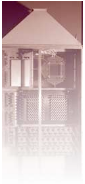

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