Machines that Learn how to Code Open-Ended Survey Data

Underlying Principles, Experimental Data, and Methodological Issues

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Conference on Optimal Methods of Coding Open-Ended Survey Data
Ann Arbor, Michigan – December 4-5, 2008

Outline

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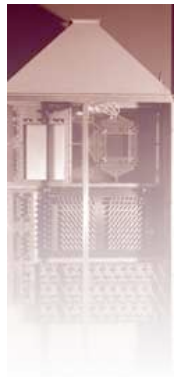

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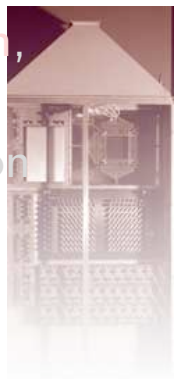

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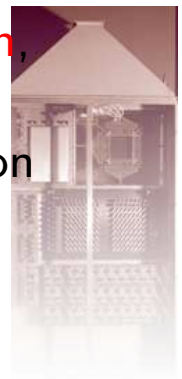

VCS (cont'd)

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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 coder for this codeframe.
- Applications include coding open-ended responses in customer satisfaction analysis, market research, and social/political studies
- 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 coder, i.e., a system that decides whether a given verbatim should or should not be attributed the code.

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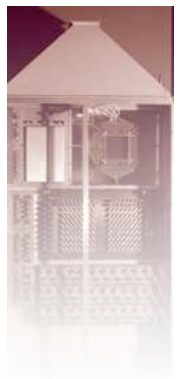
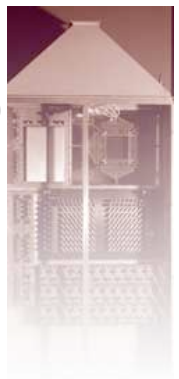


VCS: the underlying philosophy (cont'd)

- 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;
  - Coding is a subjective task, and VCS learns to replicate the subjective behaviour of the human coder who has coded the training examples;
- 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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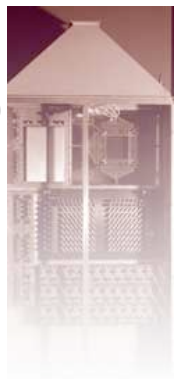

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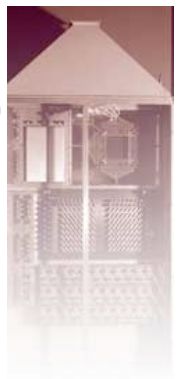

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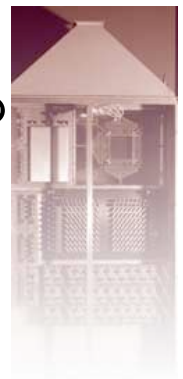


Training Phase. Teacher: "This is a tiger!"

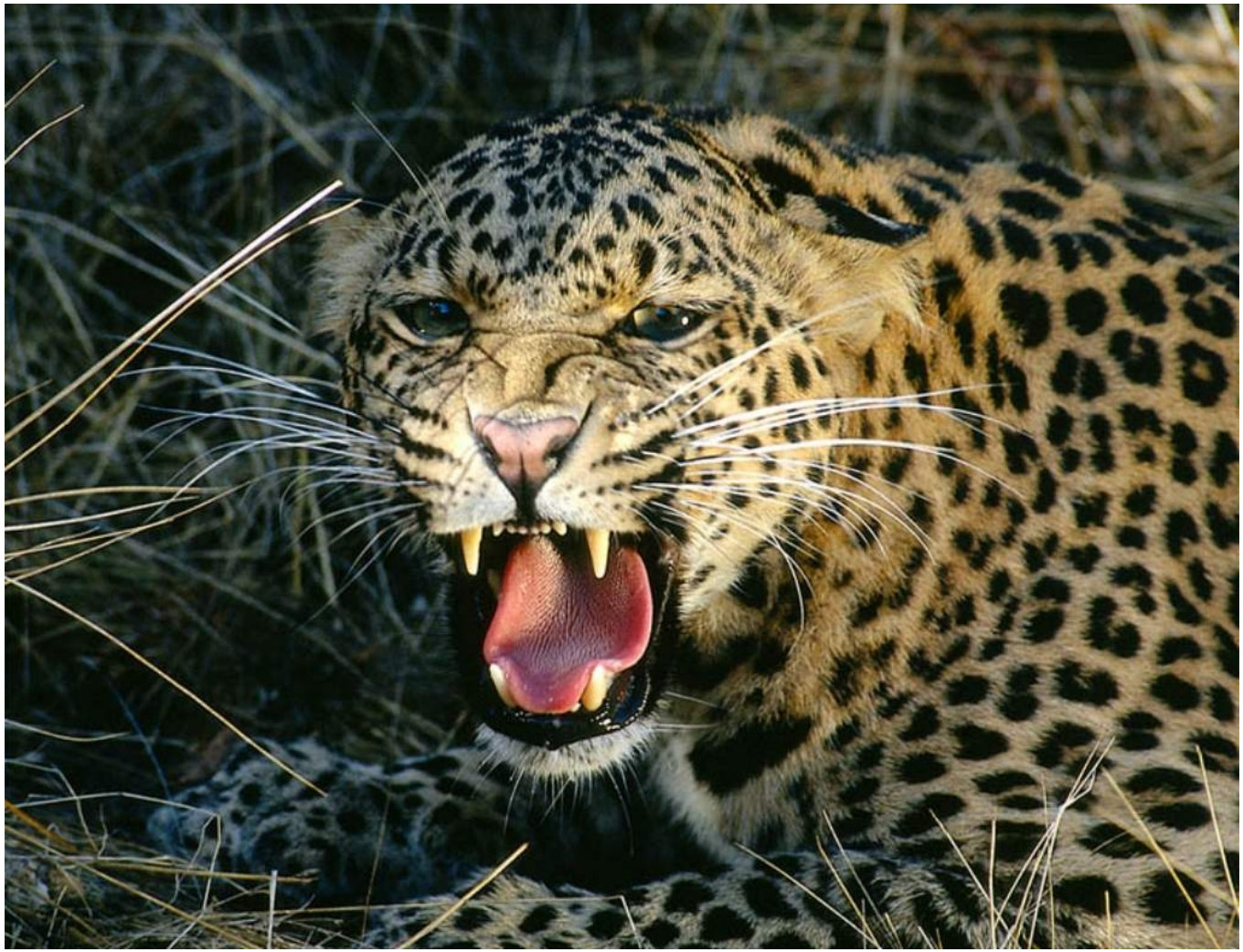
Training Phase. Teacher: "This is another tiger!"

Training Phase. Teacher: "This is yet another tiger!"

Training Phase. Teacher: "Also a tiger!"

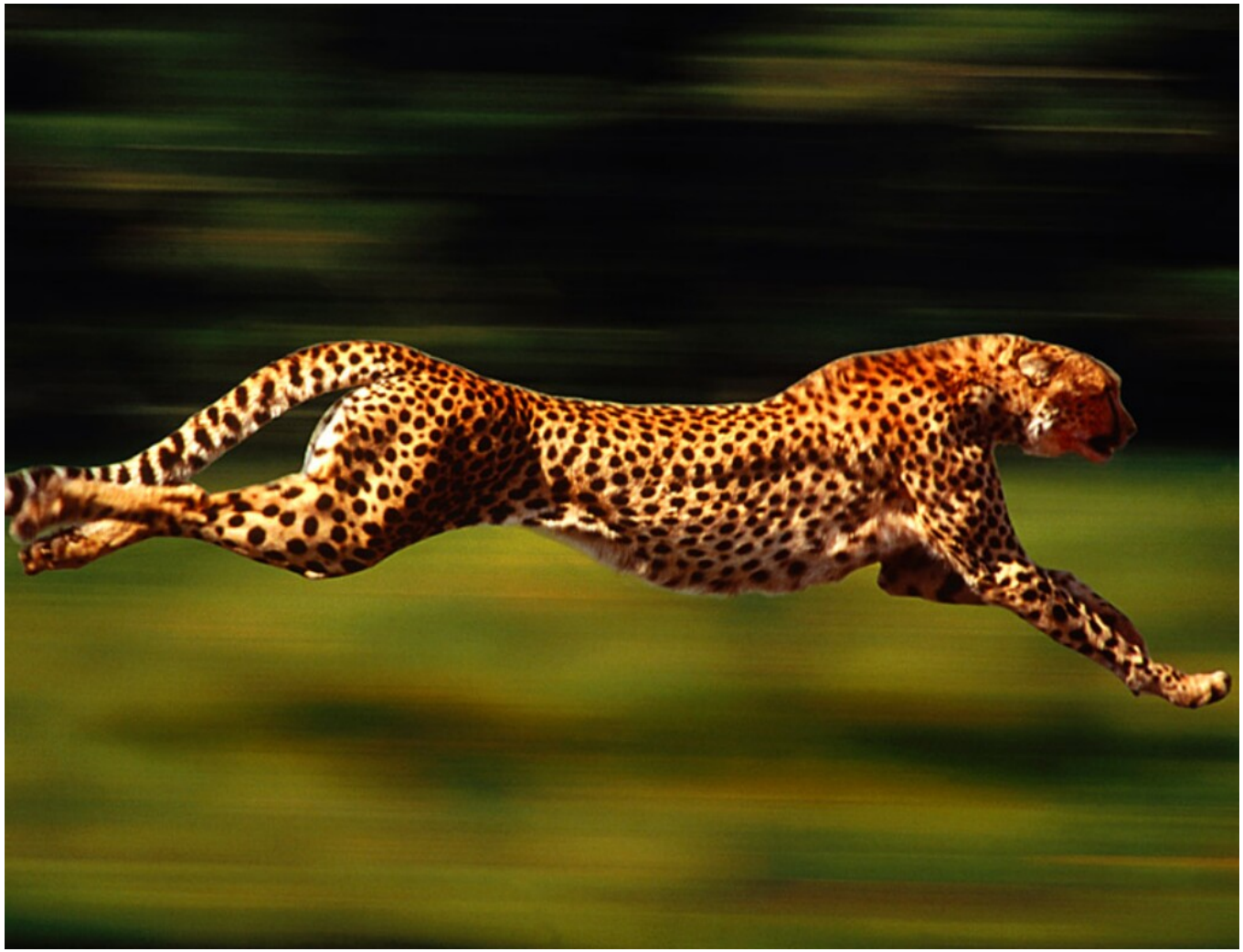
Training Phase. Teacher: "This is a NOT a tiger!"

Training Phase. Teacher: "NOT a tiger either!"



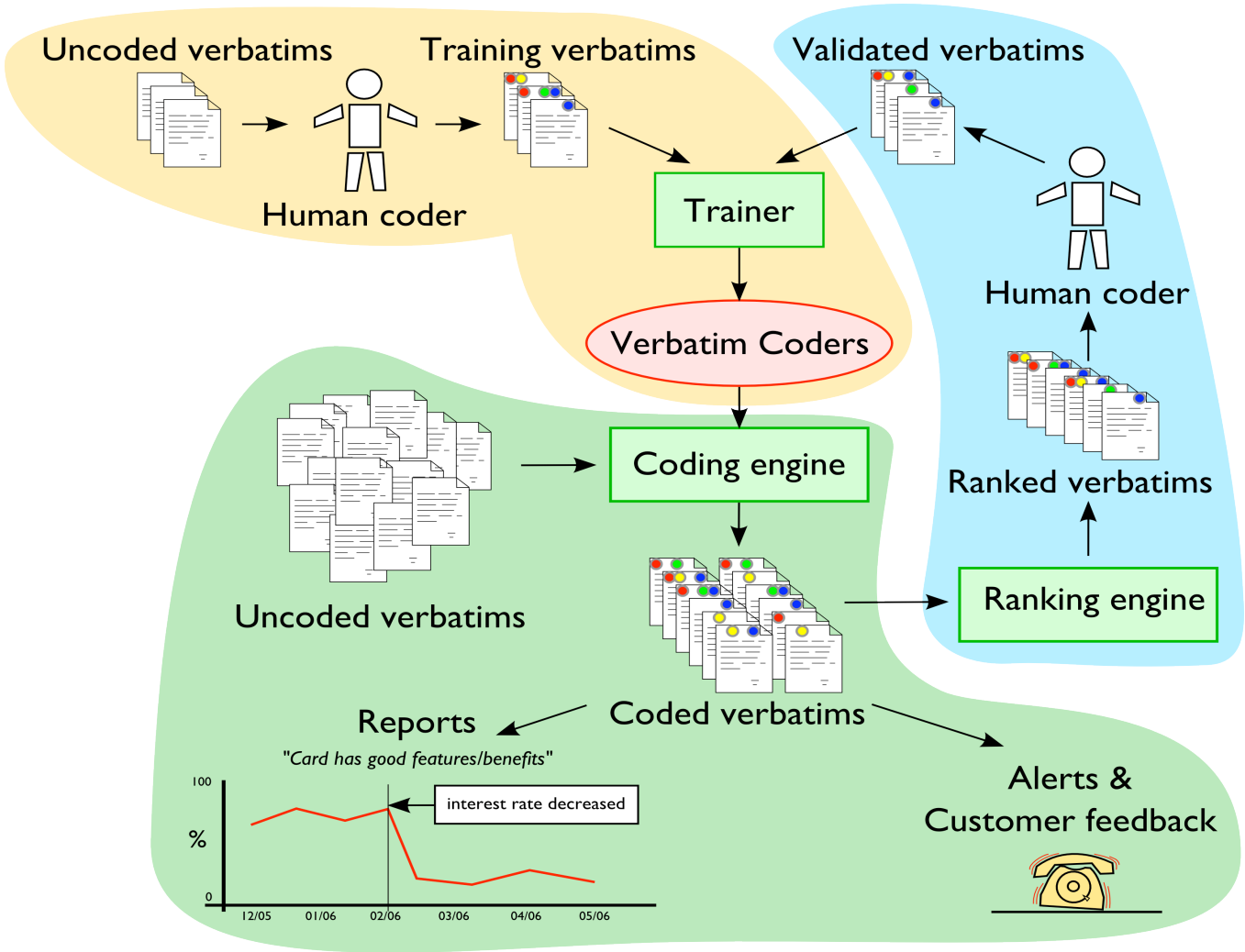
Training Phase. Teacher: "Absolutely NOT a tiger!"

Testing ("Coding") Phase. Teacher: "Is this a tiger?"



Proactive Training phase. Learner: "Is this a tiger?"

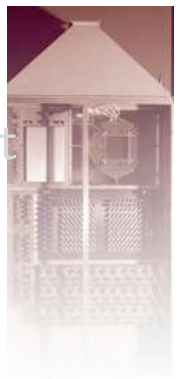
The VCS information flow



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
  - 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 domain-dependent resource (e.g, thesauri), it's a "plug and play" system;
- Pretty good accuracy at the "individual level", excellent accuracy at the "aggregate level", excellent learning and coding speed.



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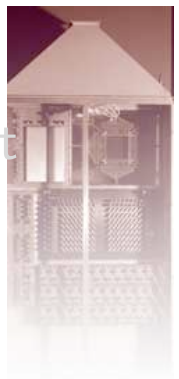

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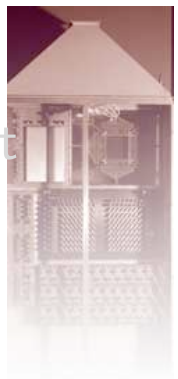

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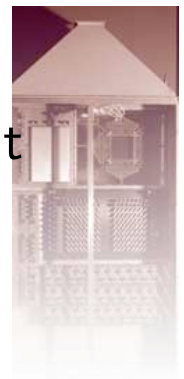

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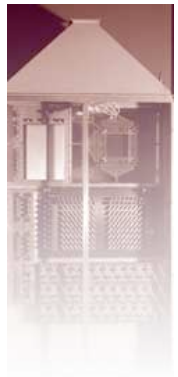

Testing accuracy

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  - At the individual level (more strict): the perfect system is the one which, for a code C, assigns C to the verbatim exactly when the human coder would have assigned C.
  - At the aggregate level (more lenient): the perfect system is the one which, for a code C, assigns $x\%$ of the verbatims to C exactly when the human coder would have assigned $x\%$ of the verbatims to C.
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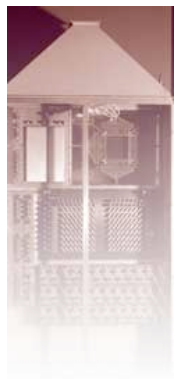

Precision and Recall

- Accuracy testing requires an accuracy 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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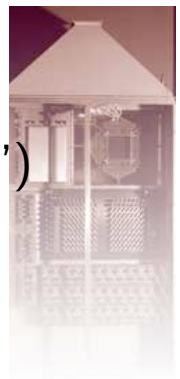

The F_1 measure

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

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

- Precision is defined as $\pi = \frac{TP}{TP + FP}$
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$$F_1 = \frac{2 \cdot \pi \cdot \rho}{\pi + \rho} = \frac{2 \cdot TP}{(2 \cdot TP) + FP + FN}$$

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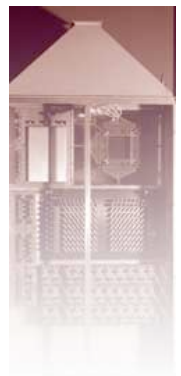

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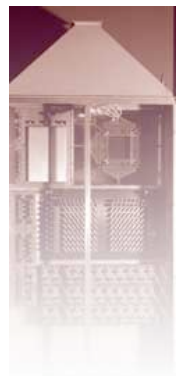


Testing accuracy on an example dataset

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

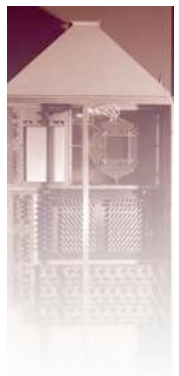
Code C_i		coder says	
		YES	**NO**
system says	**YES**	15	7
	NO	8	70

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

$$\pi = \frac{15}{15+7} = \frac{15}{22} = .682 \qquad \pi_j = \frac{22}{22+13} = \frac{22}{35} = .629$$

$$\rho = \frac{15}{15+8} = \frac{15}{23} = .652 \qquad \rho_j = \frac{22}{22+5} = \frac{22}{27} = .815$$

$$F_1 = \frac{2 \cdot .682 \cdot .652}{.682 + .652} = .667 \qquad F_1 = \frac{2 \cdot .629 \cdot .815}{.629 + .815} = .710$$



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system says	**YES**	15	7
	NO	8	70

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

$$\pi = \frac{15}{15+7} = \frac{15}{22} = .682 \qquad \pi_j = \frac{22}{22+13} = \frac{22}{35} = .629$$

$$\rho = \frac{15}{15+8} = \frac{15}{23} = .652 \qquad \rho_j = \frac{22}{22+5} = \frac{22}{27} = .815$$

$$F_1 = \frac{2 \cdot .682 \cdot .652}{.682 + .652} = .667 \qquad F_1 = \frac{2 \cdot .629 \cdot .815}{.629 + .815} = .710$$

Computing accuracy 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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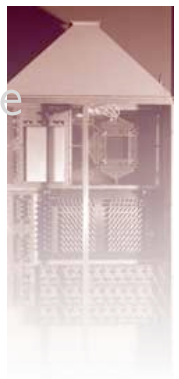
Why is F_1 a good measure of accuracy?

- $F_1 = 0$ 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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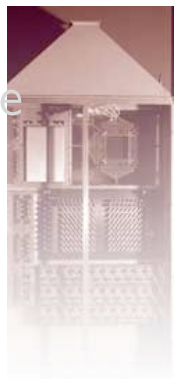

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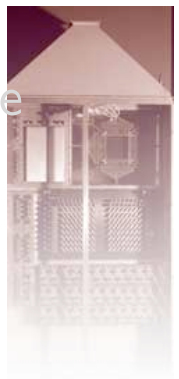

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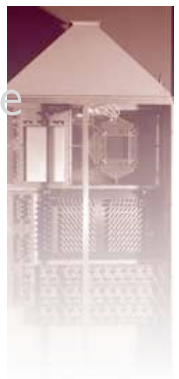

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Real tests: the Language Logic data & the Egg data

DS	$\lvert Tr \rvert$	$\lvert Te \rvert$	$\lvert C \rvert$	ATC	$\lvert D \rvert$	AVL	RAI	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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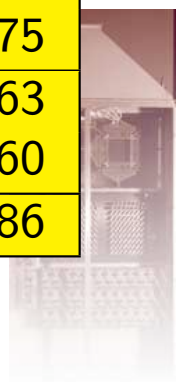

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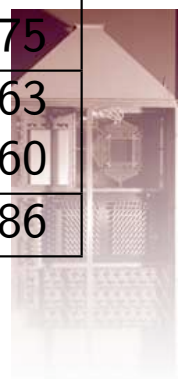

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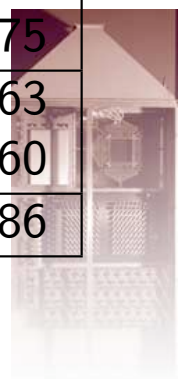

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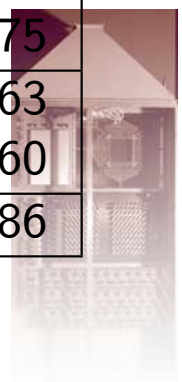

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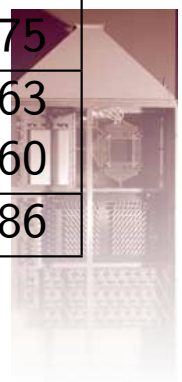

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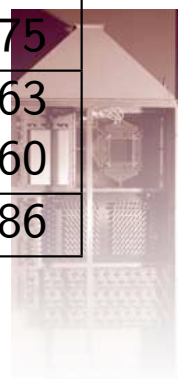

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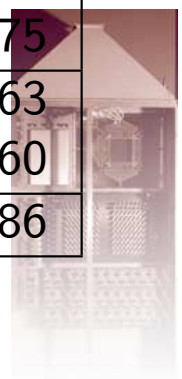
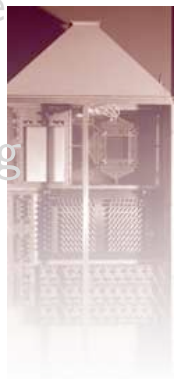


How good are these results?

- How good are $F_1 = .75$ and $F_1 = .92$?
- 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?"
  2. "Customer is ready to defect" for question "Are you happy with the quality of our service?"

  different levels of F_1 may be expected, both by an automatic coding system and by a human coder. Code 2 is inherently more controversial than Code 1.



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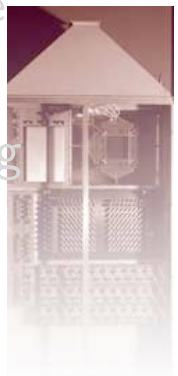

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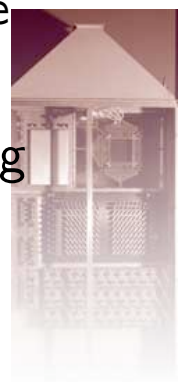

How good can be VCS expected to be on a new dataset?

- We have experimentally observed that the F_1 of VCS tends to increase with
  - the average number of training verbatims per code (ATC) provided to the system;
  - the inverse of the average length of the training verbatims (1/AVL);
  - 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.

	Easier	Harder
Average # of Training Verbatims per Code (ATC)	High	Small
Average Verbatim Length (AVL)	Small	High
Human Coder Agreement	High	Small

How good can be VCS expected to be on a new dataset?

- We have experimentally observed that the F_1 of VCS tends to increase with
  - the average number of training verbatims per code (ATC) provided to the system;
  - the inverse of the average length of the training verbatims (1/AVL);
  - 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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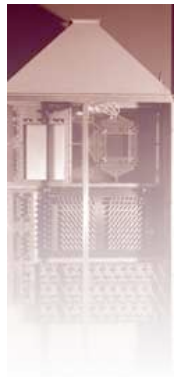
Outline



The *PD* measure

- We measure accuracy at the aggregate level by *PD*, the discrepancy between the true percentage and the predicted percentage of verbatims with code C; the perfect system has $PD = 0$.
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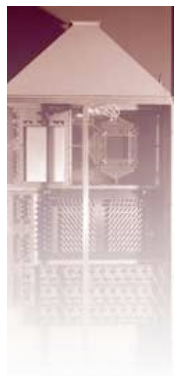
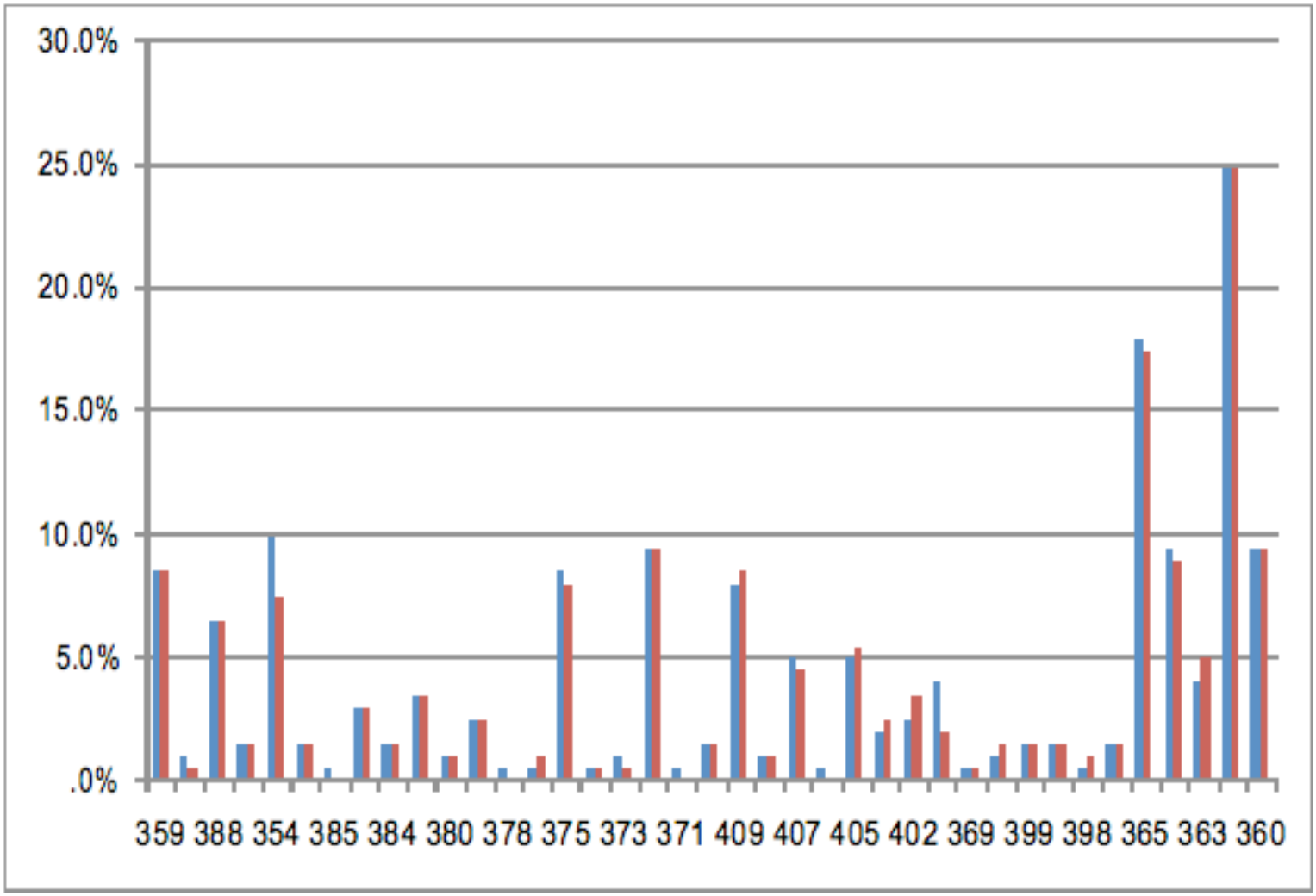
Accuracy at the aggregate level

DS	$\|C\|$	F_1^μ	AvgPD	MaxPD
LL-A	18	.92	.008	.040
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	.019	.062
Egg-B	20	.60	.023	.057
ANES L/D	1	.86	.046	.046



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 $PD = 0$!
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Outline

- There are two sides to efficiency in VCS:
  - Training-time efficiency: how fast can the automated coders for a given codeframe be generated from a given set of training verbatims?
  - Coding-time efficiency: how fast can the coders generated for a given codeframe code new, yet uncoded data?
- Our tests on Egg data indicate that, for a 20-code codeframe
  - The coders can be generated from 1000 training examples in approximately 2 minutes altogether;
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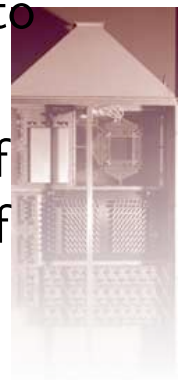

Outline

- Features I have not discussed:
  - Robustness to lexical and syntactic ill-formedness
  - Sophisticated control panel, for answering the questions
    - What F_1 / PD can I can expect on this codeframe, given the amount of training data I have provided?
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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.]*

Thanks for your attention!