Evaluating Translation Quality

February 23, 2012

Goals for this lecture

- Understanding advantages of human versus automatic evaluation
- Details of BLEU
- How to validate automatic evaluation metrics
- What makes a good {manual / automatic} evaluation?

Evaluating MT Quality

- Why do we want to do it?
  - Want to rank systems
  - Want to evaluate incremental changes
  - What to make scientific claims
- How not to do it
  - "Back translation"
  - The vodka is not good

Human Evaluation of MT v. Automatic Evaluation

- Human evaluation is
  - Ultimately what we're interested in, but
  - Very time consuming
  - Not re-usable
- Automatic evaluation is
  - Cheap and reusable, but
  - Not necessarily reliable

Manual Evaluation

Source: Estos tejidos están analizados, transformados y congelados antes de ser almacenados en Hema-Québec, que gestiona también el único banco público de sangre del cordón umbilical en Quebec.

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Goals for Automatic Evaluation

- No cost evaluation for incremental changes
- Ability to rank systems
- Ability to identify which sentences we're doing poorly on, and categorize errors
- Correlation with human judgments
- Interpretability of the score

Methodology

- Comparison against reference translations
- Intuition: closer we get to human translations, the better we're doing
- Could use WER like in speech recognition

Word Error Rate

- Levenshtein Distance (also "edit distance")
- Minimum number of insertions, substitutions, and deletions needed to transform one string into another
- Useful measure in speech recognition
  - This shows how easy it is to recognize speech
  - This shows how easy it is to wreck a nice beach

Problems with using WER for translation?

- (discuss with your neighbor)

Problems with WER

- Unlike speech recognition we don't have the assumption of
  - **exact match against the reference**
- In machine translation there can be many possible (and equally valid) ways of translating a sentence
  - This shows how easy it is to recognize speech
  - It illustrates how simple it is to transcribe the spoken word

Problems with WER

- Unlike speech recognition we don't have the assumption of
  - **linearity**
- Clauses can move around, since we're not doing transcription
  - This shows how easy it is to recognize speech
  - It is easy to recognize speech, as this shows
  - This shows that recognizing speech is easy

Solutions?

- (Talk to your neighbor)

Solutions

- Compare against lots of test sentences
- Use multiple reference translations for each test sentence
- Look for phrase / n-gram matches, allow movement

BLEU

- **B**i**L**ingual **E**valuation **U**nderstudy
- Uses multiple reference translations
- Look for n-grams that occur anywhere in the sentence

Multiple references

Ref 1	Orejuela appeared calm as he was led to the American plane which will take him to Miami, Florida.
Ref 2	Orejuela appeared calm while being escorted to the plane that would take him to Miami, Florida.
Ref 3	Orejuela appeared calm as he was being led to the American plane that was to carry him to Miami in Florida.
Ref 4	Orejuela seemed quite calm as he was being led to the American plane that would take him to Miami in Florida.

n-gram precision

$$p_n = \frac{\sum_{S \in C} \sum_{ngram \in S} Count_{matched}(ngram)}{\sum_{S \in C} \sum_{ngram \in S} Count(ngram)}$$

- BLEU modifies this precision to eliminate repetitions that occur across sentences.

Modified precision

Ref 1	Orejuela appeared calm as he was led to the American plane which will take him **to Miami**, Florida.
Ref 2	Orejuela appeared calm while being escorted to the plane that would take him **to Miami**, Florida.
Ref 3	Orejuela appeared calm as he was being led to the American plane that was to carry him **to Miami** in Florida.
Ref 4	Orejuela seemed quite calm as he was being led to the American plane that would take him **to Miami** in Florida.

"to Miami" can only be counted as correct once

Ref 1	Orejuela appeared calm as he was led to the American plane which will take him to Miami, Florida.
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Ref 4	Orejuela seemed quite calm as he was being led to the American plane that would take him to Miami in Florida.

Hyp	appeared calm when he was taken to the American plane, which will to Miami, Florida.

American, Florida, Miami, Orejuela, **appeared**, as, being, calm, carry, escorted, he, him, in, led, **plane**, quite, seemed, take, that, the, **to**, **to**, to, **was** , was, **which**, while, **will**, would, **,, .**

1-gram precision = 15/18

Hyp	**appeared calm** when **he was** taken **to the American plane** , **which will to Miami , Florida .**

American plane, **Florida .**, **Miami ,**, Miami in, Orejuela appeared, Orejuela seemed, **appeared calm**, as he, being escorted, being led, calm as, calm while, carry him, escorted to, **he was**, him to, in Florida, led to, plane that, plane which, quite calm, seemed quite, take him, that was, that would, **the American**, the plane, **to Miami**, to carry, **to the**, was being, was led, was to, **which will**, while being, will take, would take, , Florida

2-gram precision = 10/17

Hyp	**appeared calm** when **he was** taken **to the American plane** , **which will to Miami , Florida .**

n-gram precision

Hyp	appeared calm when he was taken to the American plane, which will to Miami, Florida.

1-gram precision = 15/18 = .83
2-gram precision = 10/17 = .59
3-gram precision = 5/16 = .31
4-gram precision = 3/15 = .20

- Geometric average

  exp(log .83 + log .59 + log .31 + log .2) = 0.22

Ref 1	Orejuela appeared calm as he was led to the American plane which will take him to Miami, Florida.
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Hyp	to the American plane

Better?

Hyp	to the American plane

1-gram precision = 4/4 = 1.0
2-gram precision = 3/3 = 1.0
3-gram precision = 2/2 = 1.0
4-gram precision = 1/1 = 1.0

exp(log 1 + log 1 + log 1 + log 1) = 1

Brevity Penalty

$$\mathrm{BP} = \begin{cases} 1 & \text{if} \quad c > r \\ e^{1-r/c} & \text{if} \quad c \leq r \end{cases}$$

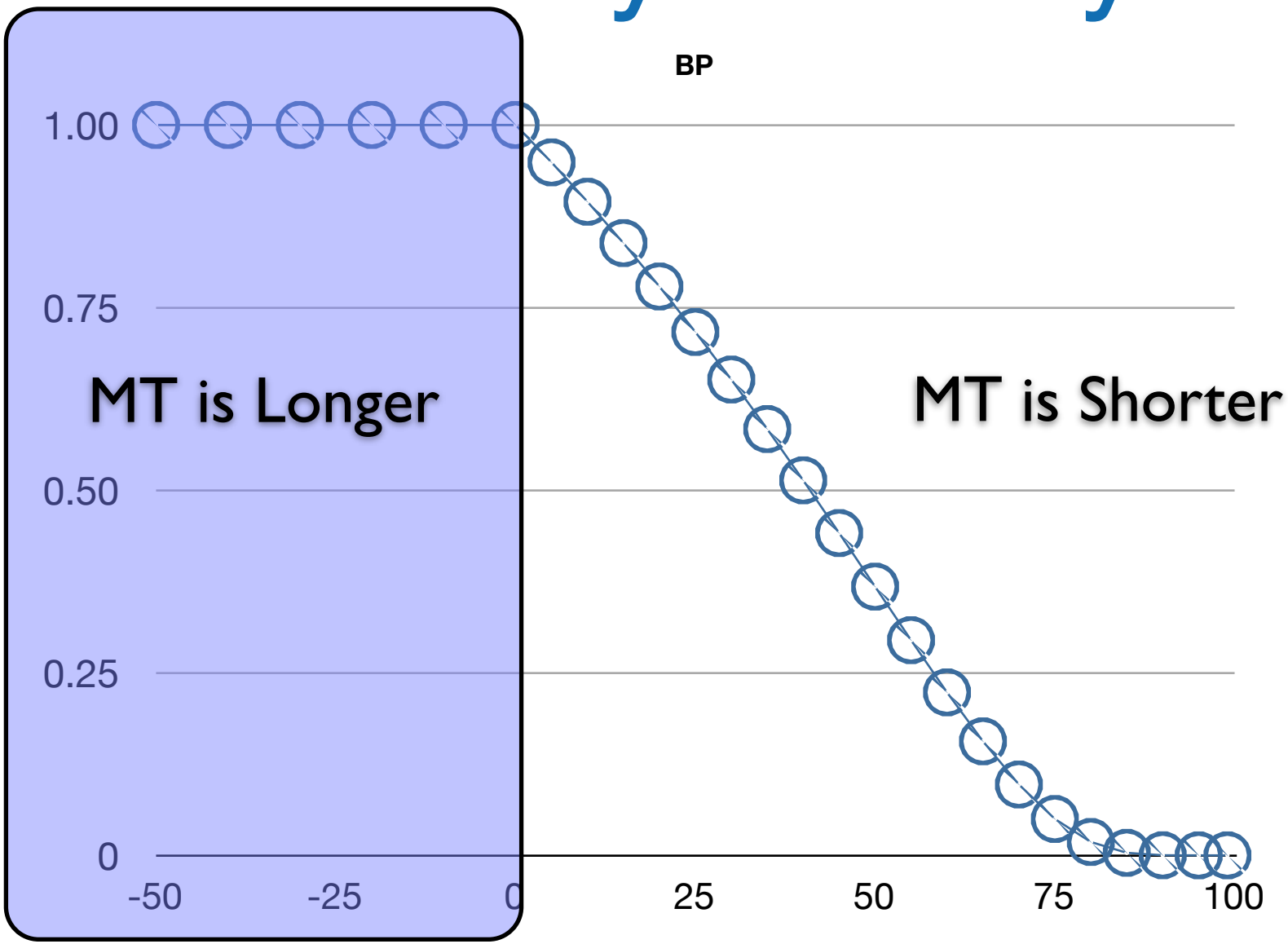
- c is the length of the corpus of hypothesis translations
- r is the effective reference corpus length

Brevity Penalty

$$\mathrm{BP} = \begin{cases} 1 & \text{if} \quad c > r \\ e^{1-r/c} & \text{if} \quad c \leq r \end{cases}$$

- c is the length of the corpus of hypothesis translations
- r is the effective reference corpus length
- The effective reference corpus length is the sum of the single reference translation from each set that is closest to the hypothesis translation.

Brevity Penalty



Difference with effective reference length (%)

Ref 1	Orejuela appeared calm as he was led to the American plane which will take him to Miami, Florida. r = 20
Hyp	appeared calm when he was taken to the American plane, which will to Miami, Florida. c = 18

BP = exp(1-(20/18)) = 0.89

Ref 1	Orejuela appeared calm as he was led to the American plane which will take him to Miami, Florida. r = 20
Hyp	to the American plane c = 4

BP = exp(1-(20/4)) = 0.02

BLEU

$$\text{Bleu} = \text{BP} * \exp\left(\sum_{n=1}^{N} w_n \log p_n\right)$$

- Geometric average of the n-gram precisions
- Optionally weight them with w
- Multiplied by the brevity penalty

BLEU

Hyp	appeared calm when he was taken to the American plane, which will to Miami, Florida.

exp(1-(20/18)) * exp(log .83 + log .59 + log .31 + log .2)

= 0.197

Hyp	to the American plane

exp(1-(20/4)) * exp(log 1 + log 1 + log 1 + log 1)

= 0.018

Problems with BLEU

- (Discuss with your neighbor)

Problems with BLEU

- Synonyms and paraphrases are only handled if they are in the set of multiple reference translations
- The scores for words are equally weighted so missing out on content-bearing material brings no additional penalty.
- The brevity penalty is a stop-gap measure to compensate for the fairly serious problem of not being able to calculate recall.

More Metrics

- WER - word error rate
- PI-WER - position independent WER
- METEOR - **M**etric for **E**valuation of **T**ranslation with **E**xplicit **OR**dering
- TERp - **T**ranslation **E**dit **R**ate **p**lus

Even More Metrics

Metric IDs	Participant
AMBER, AMBER-NL, AMBER-IT	National Research Council Canad
F15, F15G3	Koç University (Bicici and Yuret,
METEOR-1.3-ADQ, METEOR-1.3-RANK	Carnegie Mellon University (Denl
MTERATER, MTERATER-PLUS	Columbia / ETS (Parton et al., 20
MP4IBM1, MPF, WMPF	DFKI (Popović, 2011; Popović et
PARSECONF	DFKI (Avramidis et al., 2011)
ROSE, ROSE-POS	The University of Sheffield (Song
TESLA-B, TESLA-F, TESLA-M	National University of Singapore
TINE	University of Wolverhampton (Ri
BLEU	provided baseline (Papineni et al.,
TER	provided baseline (Snover et al., 2

How do we know which metric is best?

- Measure correlation with human judgments
- How do people evaluation MT quality

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5-point scales

Fluency

How do you judge the fluency of this translation?

5 = Flawless English
4 = Good English
3 = Non-native English
2 = Disfluent English
1 = Incomprehensible

Adequacy

How much of the meaning expressed in the reference translation is also expressed in the hypothesis translation?

5 = All
4 = Most
3 = Much
2 = Little
1 = None

Reading Comprehension of Machine Translation

- Jones et al (2005) - Measured translation quality by testing English speakers on a Defense Language Proficiency Test for Arabic
- Read the MT output, and assess how many questions were answered correctly
- Nice, intuitive gauge of how good MT quality actually is

Heather Locklear Arrested for driving under the influence of drugs

Heather Locklear
Photo by: Santa Barbara County Sheriff's Department

The actress Heather Locklear, Amanda of the popular series Melrose Place, was arrested this weekend in Santa Barbara (California) after driving under the influence of drugs. A witness viewed her performing inappropriate maneuvers while trying to take her car out from a parking in Montecito, as revealed to People magazine by a spokesman for the Californian Highway Police. The witness stated that around 4.30pm Ms. Locklear "hit the accelerator very violently, making excessive noise while trying to take her car out from the parking with abrupt back and forth maneuvers. While reversing, she passed several times in front of his sunglasses." Shortly after, the witness, who, in a first

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  - She was arrested on suspicion of driving under the influence of drugs.

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SPONSORED LINKS

- Why was Heather Locklear arrested?
  - She was arrested on suspicion of driving under the influence of drugs.
- Why did the bystander call emergency services?
  - He was concerned for Ms. Locklear's life.

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  - She was arrested on suspicion of driving under the influence of drugs.
- Why did the bystander call emergency services?
  - He was concerned for Ms. Locklear's life.
- Where did the witness see her acting abnormally?
  - Pulling out of parking in Montecito

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Was arrested actress Heather Locklear because of the driving under the effect of an unknown medicine

Heather Locklear
Photo by: Santa Barbara County Sheriff's Department

The actress Heather Locklear that is known to the Amanda through the role from the series "Melrose Place" was arrested at this weekend in Santa Barbara (Californium) because of the driving under the effect of an unknown medicine. A female witness observed she attempted in quite strange way how to go from their parking space in Montecito, speaker of the traffic police of californium told the warehouse `People'. The female witness told in detail, that Locklear 'pressed `after 16:30 clock accelerator and a lot of noise did when she attempted to move their car towards behind or forward from the parking space, and when it went backwards, she pulled itself together unites Male at

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SPONSORED LINKS

- Why was Heather Locklear arrested?

Driving while medicated

- Why did the bystander call emergency services?

There was a lot of noise

- Where did the witness see her acting abnormally?

In a parking lot

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- Where did the witness see her acting abnormally?

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Actress Heather Locklear was due to driving under the influence of an unknown drug arrested

Heather Locklear
Photo by: Santa Barbara County Sheriff's Department

Actress Heather Locklear, by the role of Amanda from the series "Melrose Place" is known, was this weekend in Santa Barbara (California) because of driving under the influence of an unknown drug arrested. A witness had observed how it quite strange way tried to park their extended gap in Montecito, reported spokesman for the traffic police from California to the magazine `People '. The witness told in detail that Locklear `after 16:30 clock durchdrückte pedal and a lot of noise made by trying to her car to the rear or front of the park gap to move, and when she went backwards, took it a few times in their Sunglass'. Somewhat later the witness saw the beginning of the actress

- Why was Heather Locklear arrested?
- Why did the bystander call emergency services?
- Where did the witness see her acting abnormally?

. Medikamentes unknown have the effect of a fahrens under actress heather locklear arrested

Heather Locklear
Photo by: Santa Barbara County Sheriff's Department

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Driving under the influence

Driving while medicated

DUI

Driving while using drugs

Medikamentes

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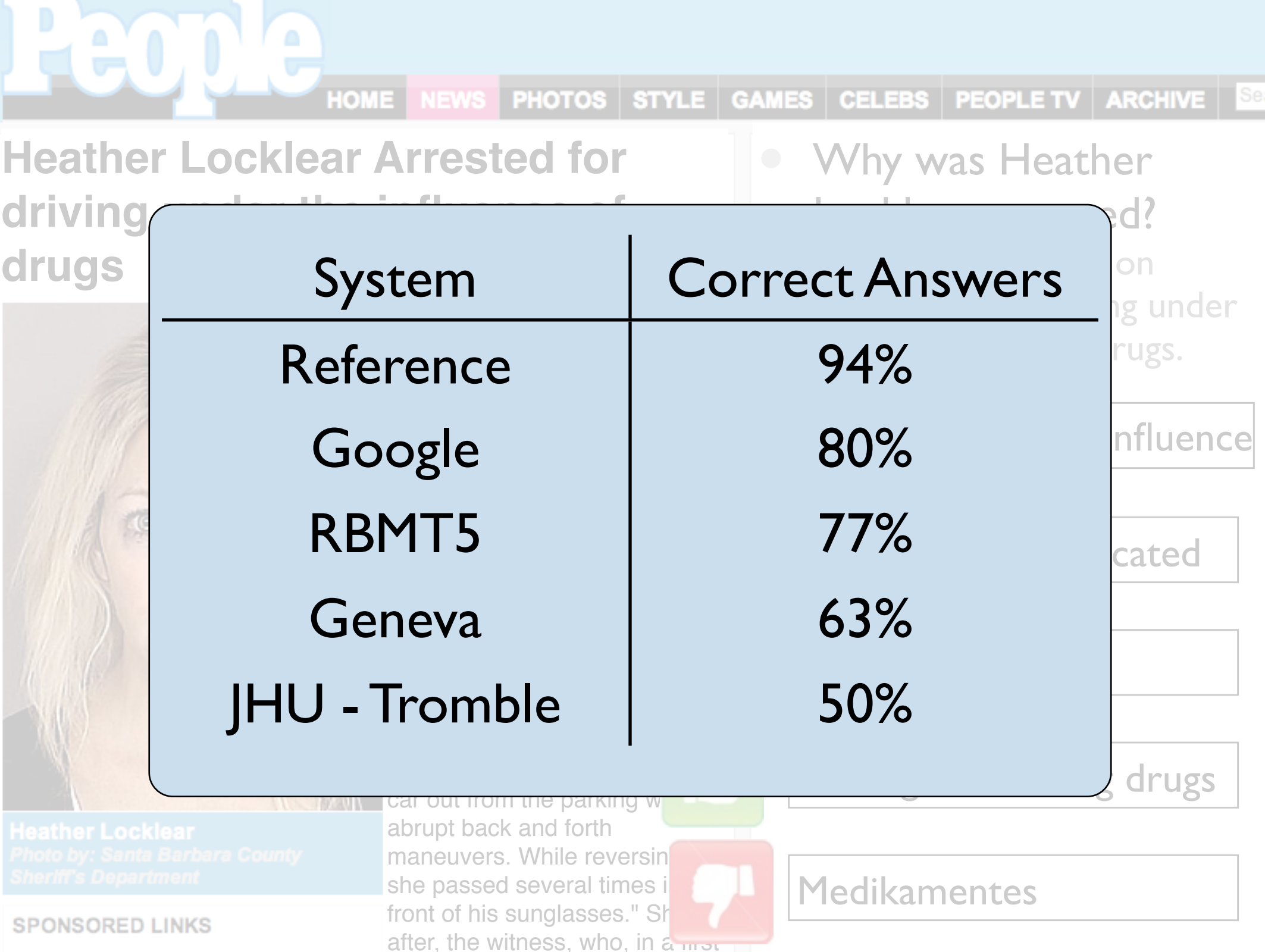
Driving while using drugs

Medikamentes



System	Correct Answers
Reference	94%
Google	80%
RBMT5	77%
Geneva	63%
JHU - Tromble	50%

HTER - costs to edit

Reference translation

The man was on assignment from the Ministry of Defense when he left two highly classified documents on a train to Waterloo.

Machine translation

The man was seconded by the Ministry of Defense when he was two extremely confidential documents in a train to Waterloo lost.

Edited machine translation

The man was seconded by the Ministry of Defense when he was two extremely confidential documents in a train to Waterloo lost.

HTER - costs to edit

Reference translation

The man was on assignment from the Ministry of Defense when he left two highly classified documents on a train to Waterloo.

Machine translation

The man was seconded by the Ministry of Defense when he was two extremely confidential documents in a train to Waterloo lost.

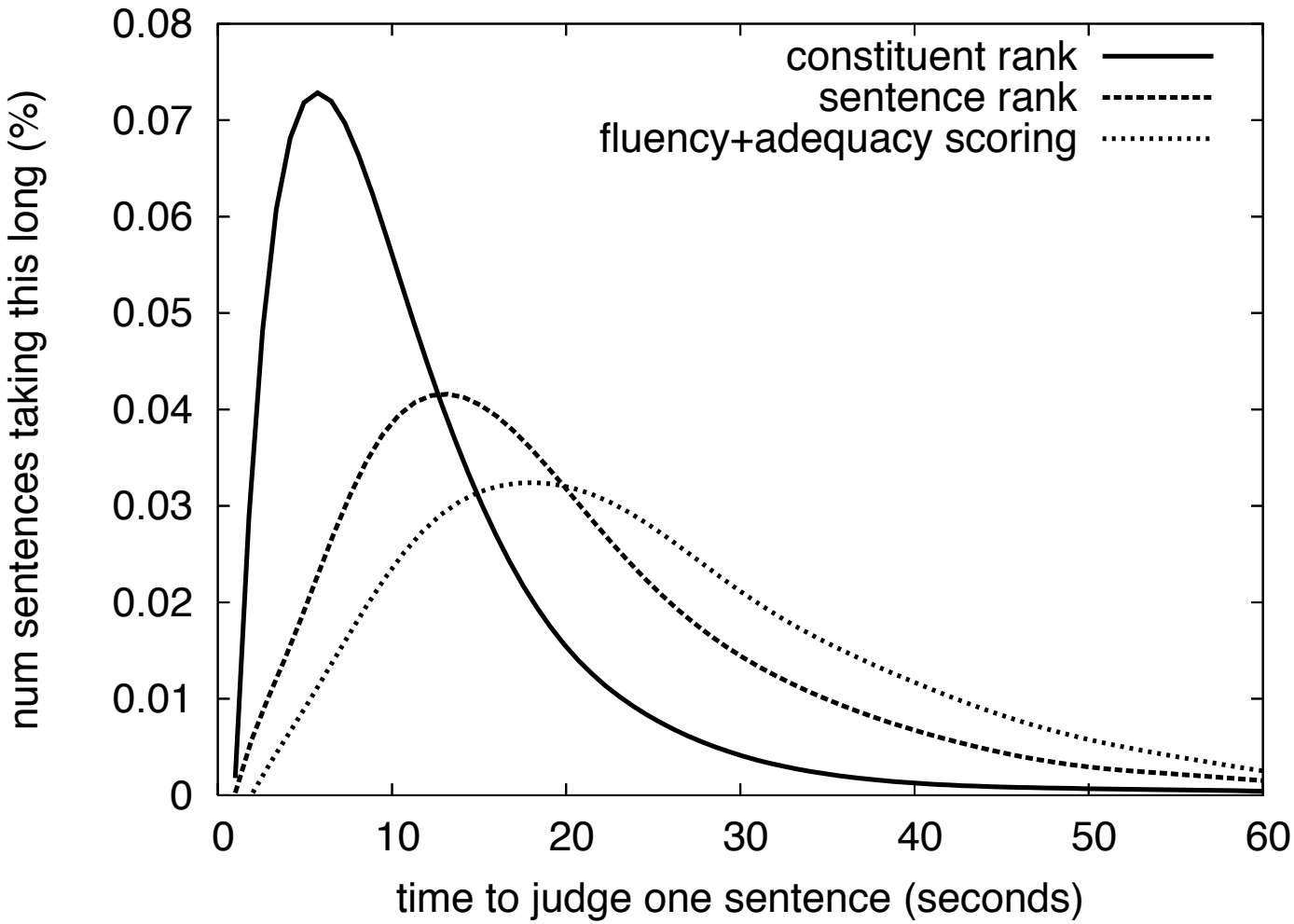
Edited machine translation

The man was **working for** the Ministry of Defense when he **lost** two extremely confidential documents in a train to Waterloo.

Which type of Human Evaluation is Best?

Evaluation type	$P(A)$	$P(E)$	K
Fluency (absolute)	.400	.2	.250
Adequacy (absolute)	.380	.2	.226
Fluency (relative)	.520	.333	.281
Adequacy (relative)	.538	.333	.307
Sentence ranking	.582	.333	.373
Constituent ranking	.693	.333	.540

Which type of Human Evaluation is Best?



Back to automatic metrics...

- Measure correlation with human judgments
- System-level correlation
- Sentence-level correlation

Calculating Correlation

- The human evaluation metrics provide a ranking of the systems
  - So do the automatic metrics
- Calculate the correlation between the two lists
  - Metrics with higher correlation better predict human judgments

Spearman's rank correlation coefficient

- For system-level correlation

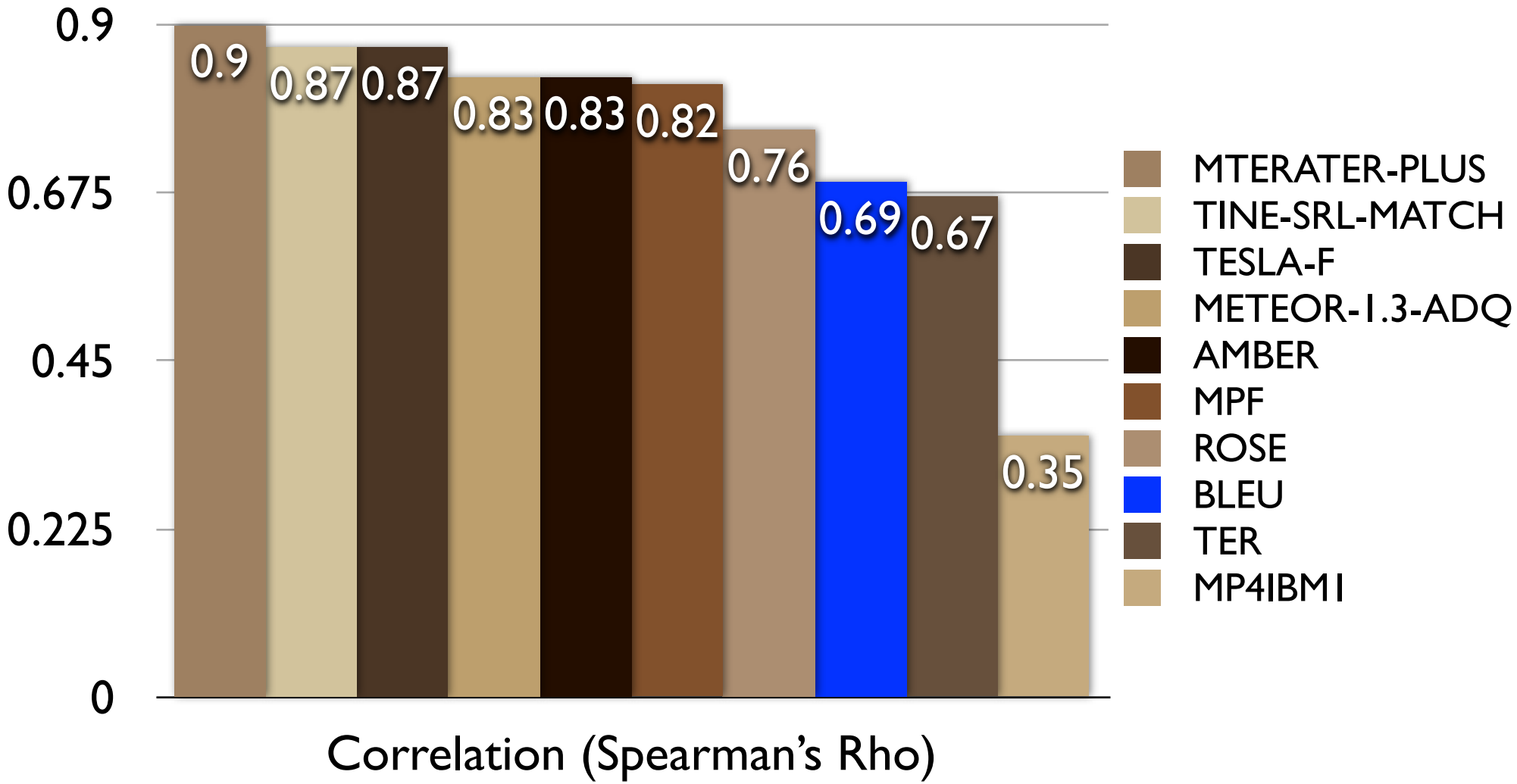
$$\rho = 1 - \frac{6 \sum d_i^2}{n(n^2 - 1)}$$

Kendall's Tau

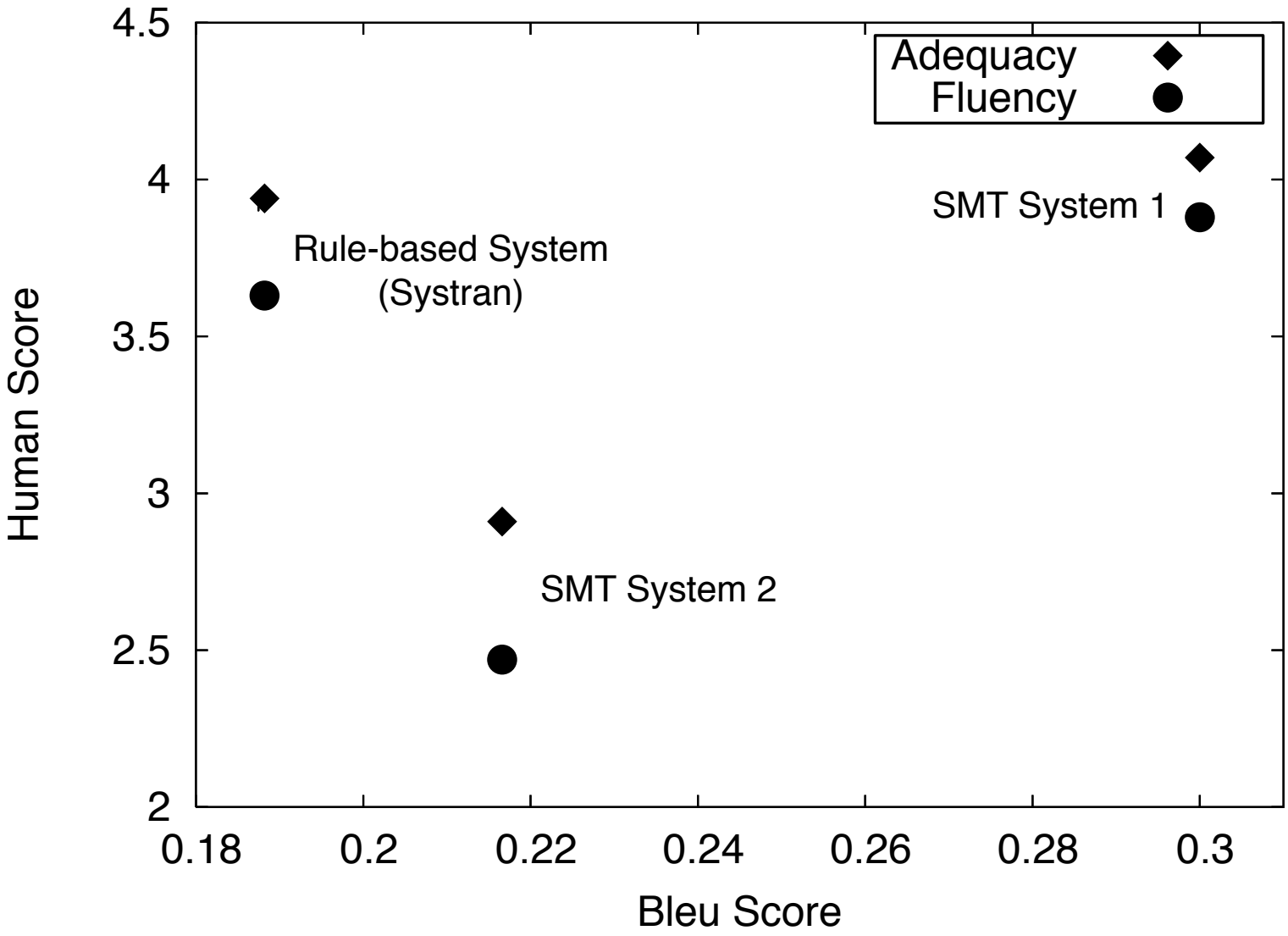
- Segment level evaluation

$$\tau = \frac{\text{num concordant pairs - num discordant pairs}}{\text{total pairs}}$$

Many metrics are better than BLEU



This is bad


Adequacy
Fluency
SMT System 1
Rule-based System
(Systran)
SMT System 2
Human Score
Bleu Score
4.5
4
3.5
3
2.5
2
0.18
0.2
0.22
0.24
0.26
0.28
0.3

Re-evaluating the Role of BLEU in Machine Translation Research

Chris Callison-Burch **Miles Osborne** **Philipp Koehn**

If Bleu's correlation with human judgments has been overestimated, then the field needs to ask itself whether it should continue to be driven by Bleu to the extent that it currently is. In this paper we give a number of counterexamples for Bleu's correlation with human judgments. We show that under some circumstances an improvement in Bleu is *not sufficient* to reflect a genuine improvement in translation quality, and in other circumstances that it is *not necessary* to improve Bleu in order to achieve a noticeable improvement in translation quality.

Final thoughts on Evaluation

When writing a paper

- If you're writing a paper that claims that
  - one approach to machine translation is better than another, or that
  - some modification you've made to a system has improved translation quality
- Then you need to back up that claim
- Evaluation metrics can help, but good experimental design is also critical

Experimental Design

- Importance of separating out training / test / development sets
- Importance of standardized data sets
- Importance of standardized evaluation metric
- Error analysis
- Statistical significance tests for differences between systems

Evaluation drives MT research

- Metrics can drive the research for the topics that they evaluate
- NIST MT Eval -> DARPA Funding
- Bleu has lead to a focus on phrase-based translation
- Minimum error rate training (next lecture!)
- Other metrics may similarly change the community's focus

Invent your own evaluation metric

- If you think that Bleu is inadequate then invent your own automatic evaluation metric
- Can it be applied automatically?
- Does it correlate better with human judgment?
- Does it give a finer grained analysis of mistakes?

Goals for Automatic Evaluation

- No cost evaluation for incremental changes
- Ability to rank systems
- Ability to identify which sentences we're doing poorly on, and categorize errors
- Correlation with human judgments
- Interpretability of the score
- Quick to calculate for MERT

Questions?

- Tons of data available at
- http://statmt.org/wmt10/results.html