
Evaluation

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- How good is a given machine translation system?
- Hard problem, since many different translations acceptable
→ semantic equivalence / similarity
- Evaluation metrics
 - subjective judgments by human evaluators
 - automatic evaluation metrics
 - task-based evaluation, e.g.:
 - how much post-editing effort?
 - does information come across?

Ten Translations of a Chinese Sentence



这个 机场 的 安全 工作 由 以色列 方面 负责 .

Iraqi officials are responsible for airport security.

Iraq is in charge of the security at this airport.

The security work for this airport is the responsibility of the Iraq government.

Iraqi side was in charge of the security of this airport.

Iraq is responsible for the airport's security.

Iraq is responsible for safety work at this airport.

Iraq presides over the security of the airport.

Iraq took charge of the airport security.

The safety of this airport is taken charge of by Iraq

This airport's security is the responsibility of the Iraqi security officials.

adequacy and fluency

Adequacy and Fluency



- Human judgement
 - given: machine translation output
 - given: source and/or reference translation
 - task: assess the quality of the machine translation output

- Metrics

Adequacy: Does the output convey the same meaning as the input sentence?
Is part of the message lost, added, or distorted?

Fluency: Is the output good fluent English?
This involves both grammatical correctness and idiomatic word choices.

Fluency and Adequacy: Scales

| Adequacy | |
|-----------------|----------------|
| 5 | all meaning |
| 4 | most meaning |
| 3 | much meaning |
| 2 | little meaning |
| 1 | none |

| Fluency | |
|----------------|--------------------|
| 5 | flawless English |
| 4 | good English |
| 3 | non-native English |
| 2 | disfluent English |
| 1 | incomprehensible |

Annotation Tool

Judge Sentence

You have already judged 14 of 3064 sentences, taking 86.4 seconds per sentence.

Source: les deux pays constituent plutôt un laboratoire nécessaire au fonctionnement interne de l'ue .

Reference: rather , the two countries form a laboratory needed for the internal working of the eu .

| Translation | Adequacy | Fluency |
|---|---|---|
| both countries are rather a necessary laboratory the internal operation of the eu . | <input type="radio"/> <input type="radio"/> <input type="radio"/> <input type="radio"/> <input checked="" type="radio"/> 1 2 3 4 5 | <input type="radio"/> <input type="radio"/> <input type="radio"/> <input type="radio"/> <input checked="" type="radio"/> 1 2 3 4 5 |
| both countries are a necessary laboratory at internal functioning of the eu . | <input type="radio"/> <input type="radio"/> <input checked="" type="radio"/> <input type="radio"/> <input type="radio"/> 1 2 3 4 5 | <input type="radio"/> <input type="radio"/> <input checked="" type="radio"/> <input type="radio"/> <input type="radio"/> 1 2 3 4 5 |
| the two countries are rather a laboratory necessary for the internal workings of the eu . | <input type="radio"/> <input type="radio"/> <input type="radio"/> <input checked="" type="radio"/> <input type="radio"/> 1 2 3 4 5 | <input type="radio"/> <input type="radio"/> <input type="radio"/> <input checked="" type="radio"/> <input type="radio"/> 1 2 3 4 5 |
| the two countries are rather a laboratory for the internal workings of the eu . | <input type="radio"/> <input type="radio"/> <input checked="" type="radio"/> <input type="radio"/> <input type="radio"/> 1 2 3 4 5 | <input type="radio"/> <input type="radio"/> <input type="radio"/> <input type="radio"/> <input checked="" type="radio"/> 1 2 3 4 5 |
| the two countries are rather a necessary laboratory internal workings of the eu . | <input type="radio"/> <input type="radio"/> <input checked="" type="radio"/> <input type="radio"/> <input type="radio"/> 1 2 3 4 5 | <input type="radio"/> <input type="radio"/> <input checked="" type="radio"/> <input type="radio"/> <input type="radio"/> 1 2 3 4 5 |
| Annotator: Philipp Koehn Task: WMT06 French-English | Annotate | |
| Instructions | 5= All Meaning 4= Most Meaning 3= Much Meaning 2= Little Meaning 1= None | 5= Flawless English 4= Good English 3= Non-native English 2= Disfluent English 1= Incomprehensible |

Hands On: Judge Translations



- Rank according to adequacy and fluency on a 1-5 scale (5 is best)
 - Source:
L'affaire NSA souligne l'absence totale de débat sur le renseignement
 - Reference:
NSA Affair Emphasizes Complete Lack of Debate on Intelligence
 - System1:
The NSA case underscores the total lack of debate on intelligence
 - System2:
The case highlights the NSA total absence of debate on intelligence
 - System3:
The matter NSA underlines the total absence of debates on the piece of information

Hands On: Judge Translations



- Rank according to adequacy and fluency on a 1-5 scale (5 is best)
 - Source:
N'y aurait-il pas comme une vague hypocrisie de votre part ?
 - Reference:
Is there not an element of hypocrisy on your part?
 - System1:
Would it not as a wave of hypocrisy on your part?
 - System2:
Is there would be no hypocrisy like a wave of your hand?
 - System3:
Is there not as a wave of hypocrisy from you?

Hands On: Judge Translations



- Rank according to adequacy and fluency on a 1-5 scale (5 is best)
 - Source:

La France a-t-elle bénéficié d'informations fournies par la NSA concernant des opérations terroristes visant nos intérêts ?
 - Reference:

Has France benefited from the intelligence supplied by the NSA concerning terrorist operations against our interests?
 - System1:

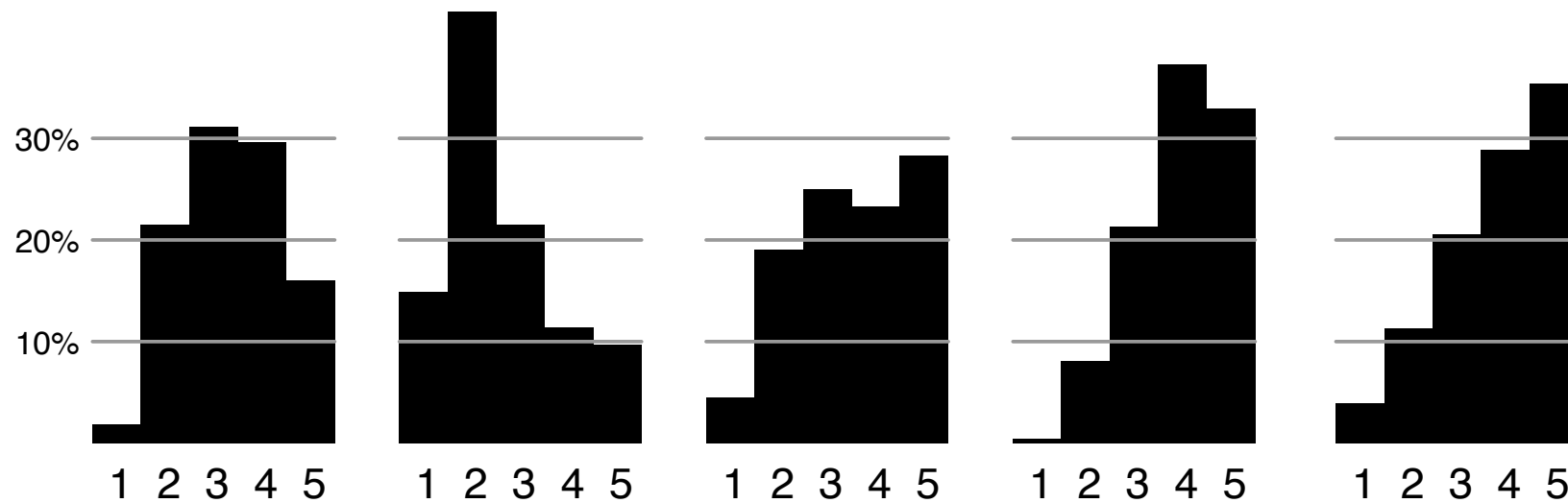
France has benefited from information supplied by the NSA on terrorist operations against our interests?
 - System2:

Has the France received information from the NSA regarding terrorist operations aimed our interests?
 - System3:

Did France profit from furnished information by the NSA concerning of the terrorist operations aiming our interests?

Evaluators Disagree

- Histogram of adequacy judgments by different human evaluators



(from WMT 2006 evaluation)

Measuring Agreement between Evaluators

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- Kappa coefficient

$$K = \frac{p(A) - p(E)}{1 - p(E)}$$

- $p(A)$: proportion of times that the evaluators agree
 - $p(E)$: proportion of time that they would agree by chance
(5-point scale $\rightarrow p(E) = \frac{1}{5}$)
- Example: Inter-evaluator agreement in WMT 2007 evaluation campaign

| Evaluation type | $P(A)$ | $P(E)$ | K |
|-----------------|--------|--------|------|
| Fluency | .400 | .2 | .250 |
| Adequacy | .380 | .2 | .226 |

Ranking Translations

- Task for evaluator: Is translation X better than translation Y?
(choices: better, worse, equal)
- Evaluators are more consistent:

| Evaluation type | $P(A)$ | $P(E)$ | K |
|------------------|--------|--------|------|
| Fluency | .400 | .2 | .250 |
| Adequacy | .380 | .2 | .226 |
| Sentence ranking | .582 | .333 | .373 |

Ways to Improve Consistency

- Evaluate fluency and adequacy separately
- Normalize scores
 - use 100-point scale with "analog" ruler
 - normalize mean and variance of evaluators
- Check for bad evaluators (e.g., when using Amazon Turk)
 - repeat items
 - include reference
 - include artificially degraded translations

Goals for Evaluation Metrics

Low cost: reduce time and money spent on carrying out evaluation

Tunable: automatically optimize system performance towards metric

Meaningful: score should give intuitive interpretation of translation quality

Consistent: repeated use of metric should give same results

Correct: metric must rank better systems higher

Other Evaluation Criteria

When deploying systems, considerations go beyond quality of translations

Speed: we prefer faster machine translation systems

Size: fits into memory of available machines (e.g., handheld devices)

Integration: can be integrated into existing workflow

Customization: can be adapted to user's needs

automatic metrics

Automatic Evaluation Metrics

- Goal: computer program that computes the quality of translations
- Advantages: low cost, tunable, consistent
- Basic strategy
 - given: machine translation output
 - given: human reference translation
 - task: compute similarity between them

Precision and Recall of Words

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SYSTEM A: Iraqi officials responsibility of airport safety

REFERENCE: Iraqi officials are responsible for airport security

Diagram illustrating word alignment between SYSTEM A and REFERENCE. Lines connect 'Iraqi' to 'Iraqi', 'officials' to 'officials', and 'airport' to 'airport'. The words 'responsibility', 'of', and 'safety' in SYSTEM A are red, while 'officials' and 'airport' are green. In the REFERENCE, 'Iraqi' is blue, 'officials' is black, 'are' is black, 'responsible' is black, 'for' is black, 'airport' is black, and 'security' is black.

- Precision

$$\frac{\text{correct}}{\text{output-length}} = \frac{3}{6} = 50\%$$

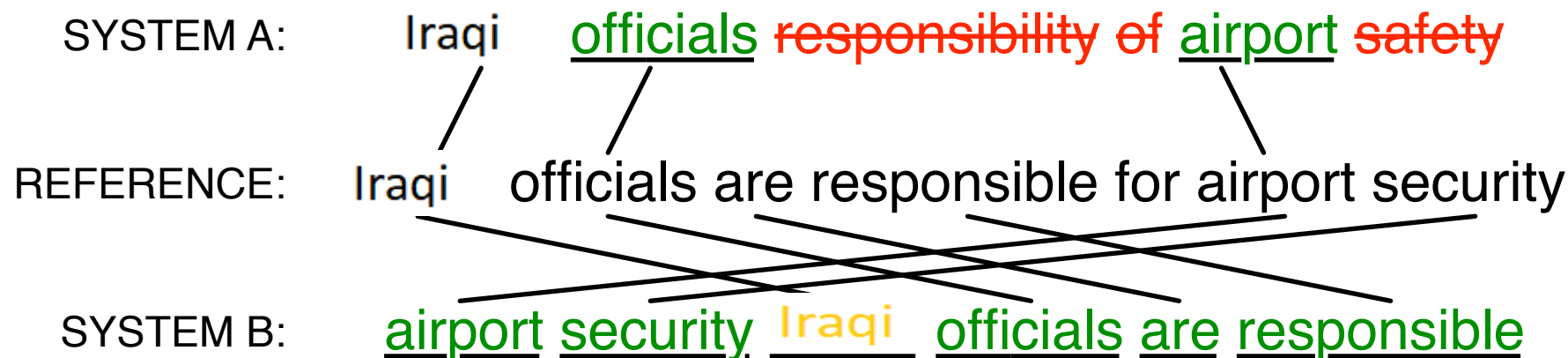
- Recall

$$\frac{\text{correct}}{\text{reference-length}} = \frac{3}{7} = 43\%$$

- F-measure

$$\frac{\text{precision} \times \text{recall}}{(\text{precision} + \text{recall})/2} = \frac{.5 \times .43}{(.5 + .43)/2} = 46\%$$

Precision and Recall



| Metric | System A | System B |
|-----------|----------|----------|
| precision | 50% | 100% |
| recall | 43% | 100% |
| f-measure | 46% | 100% |

flaw: no penalty for reordering

- Minimum number of editing steps to transform output to reference

match: words match, no cost

substitution: replace one word with another

insertion: add word

deletion: drop word

- Levenshtein distance

$$\text{WER} = \frac{\textit{substitutions} + \textit{insertions} + \textit{deletions}}{\textit{reference-length}}$$

Example

| | | | | | | | |
|-------------|---|-------|-----------|----------------|----|---------|--------|
| | | Iraqi | officials | responsibility | of | airport | safety |
| | 0 | 1 | 2 | 3 | 4 | 5 | 6 |
| Iraqi | 1 | 0 | 1 | 2 | 3 | 4 | 5 |
| officials | 2 | 1 | 0 | 1 | 2 | 3 | 4 |
| are | 3 | 2 | 1 | 1 | 2 | 3 | 4 |
| responsible | 4 | 3 | 2 | 2 | 2 | 3 | 4 |
| for | 5 | 4 | 3 | 3 | 3 | 3 | 4 |
| airport | 6 | 5 | 4 | 4 | 4 | 3 | 4 |
| security | 7 | 6 | 5 | 5 | 5 | 4 | 4 |

| | | | | | | | |
|-------------|---|---------|----------|-------|-----------|-----|-------------|
| | | airport | security | Iraqi | officials | are | responsible |
| | 0 | 1 | 2 | 3 | 4 | 5 | 6 |
| Iraqi | 1 | 1 | 2 | 2 | 3 | 4 | 5 |
| officials | 2 | 2 | 2 | 3 | 2 | 3 | 4 |
| are | 3 | 3 | 3 | 3 | 3 | 2 | 3 |
| responsible | 4 | 4 | 4 | 4 | 4 | 3 | 2 |
| for | 5 | 5 | 5 | 5 | 5 | 4 | 3 |
| airport | 6 | 5 | 6 | 6 | 6 | 5 | 4 |
| security | 7 | 6 | 5 | 6 | 7 | 6 | 5 |

| Metric | System A | System B |
|-----------------------|----------|----------|
| word error rate (WER) | 57% | 71% |

- N-gram overlap between machine translation output and reference translation
- Compute precision for n-grams of size 1 to 4
- Add brevity penalty (for too short translations)

$$\text{BLEU} = \min \left(1, \frac{\text{output-length}}{\text{reference-length}} \right) \left(\prod_{i=1}^4 \text{precision}_i \right)^{\frac{1}{4}}$$

- Typically computed over the entire corpus, not single sentences

Example

SYSTEM A: Iraqi officials responsibility of airport safety
2-GRAM MATCH 1-GRAM MATCH

REFERENCE: Iraqi officials are responsible for airport security

SYSTEM B: airport security Iraqi officials are responsible
2-GRAM MATCH 4-GRAM MATCH

| Metric | System A | System B |
|-------------------|----------|----------|
| precision (1gram) | 3/6 | 6/6 |
| precision (2gram) | 1/5 | 4/5 |
| precision (3gram) | 0/4 | 2/4 |
| precision (4gram) | 0/3 | 1/3 |
| brevity penalty | 6/7 | 6/7 |
| BLEU | 0% | 52% |

Multiple Reference Translations

- To account for variability, use multiple reference translations
 - n-grams may match in any of the references
 - closest reference length used
- Example

SYSTEM:

Iraqi officials responsibility of airport safety
2-GRAM MATCH 2-GRAM MATCH 1-GRAM

REFERENCES:

Iraqi officials are responsible for airport security
Israel is in charge of the security at this airport
The security work for this airport is the responsibility of the Iraq government
Iraqi side was in charge of the security of this airport

METEOR: Flexible Matching

- Partial credit for matching stems

| | |
|-----------|---------------|
| SYSTEM | Jim went home |
| REFERENCE | Joe goes home |

- Partial credit for matching synonyms

| | |
|-----------|----------------|
| SYSTEM | Jim walks home |
| REFERENCE | Joe goes home |

- Use of paraphrases

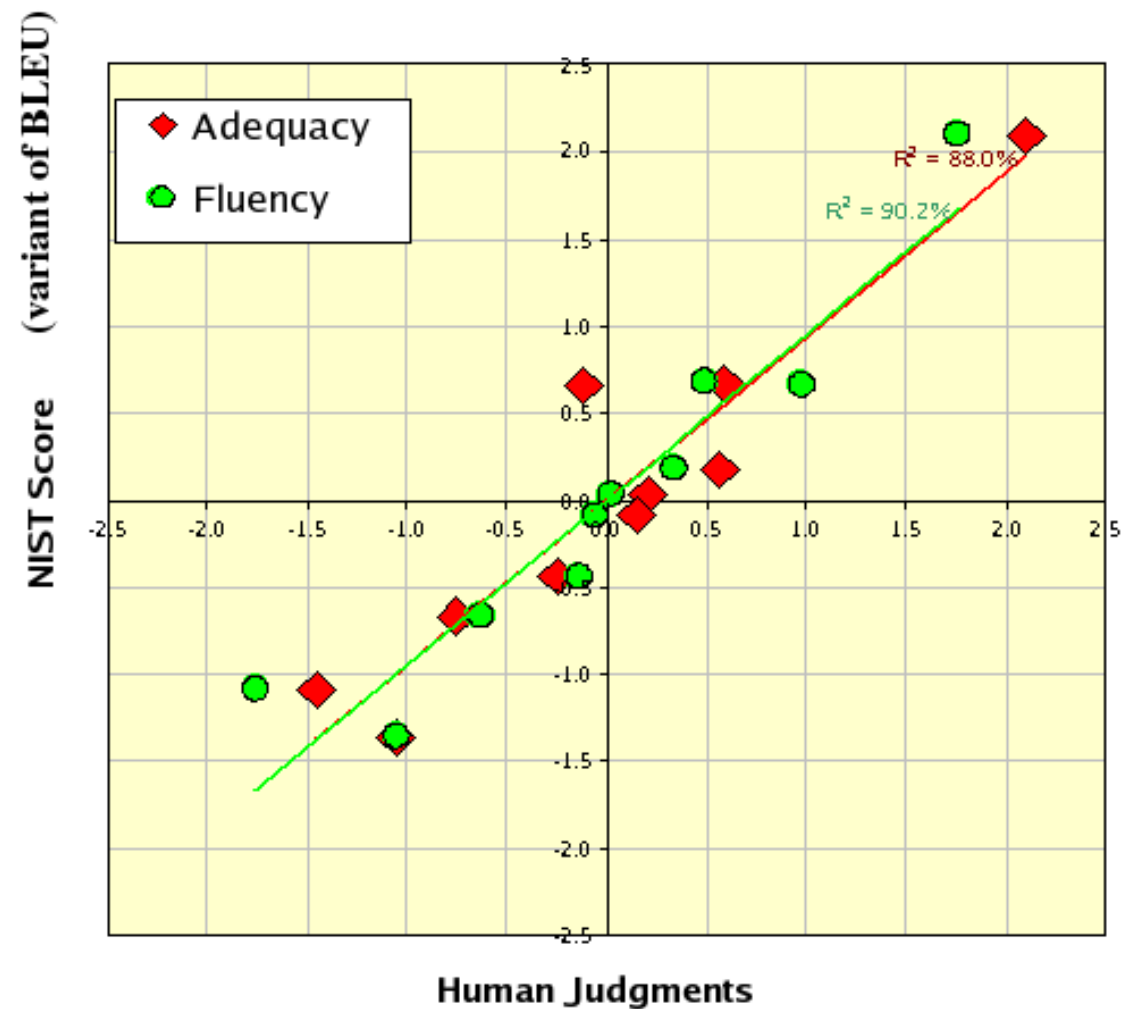
Critique of Automatic Metrics

- Ignore relevance of words
(names and core concepts more important than determiners and punctuation)
- Operate on local level
(do not consider overall grammaticality of the sentence or sentence meaning)
- Scores are meaningless
(scores very test-set specific, absolute value not informative)
- Human translators score low on BLEU
(possibly because of higher variability, different word choices)

Evaluation of Evaluation Metrics

- Automatic metrics are low cost, tunable, consistent
 - But are they correct?
- Yes, if they correlate with human judgement

Correlation with Human Judgement



Pearson's Correlation Coefficient

- Two variables: automatic score x , human judgment y
- Multiple systems $(x_1, y_1), (x_2, y_2), \dots$
- Pearson's correlation coefficient r_{xy} :

$$r_{xy} = \frac{\sum_i (x_i - \bar{x})(y_i - \bar{y})}{(n - 1) s_x s_y}$$

- Note:

$$\text{mean } \bar{x} = \frac{1}{n} \sum_{i=1}^n x_i$$

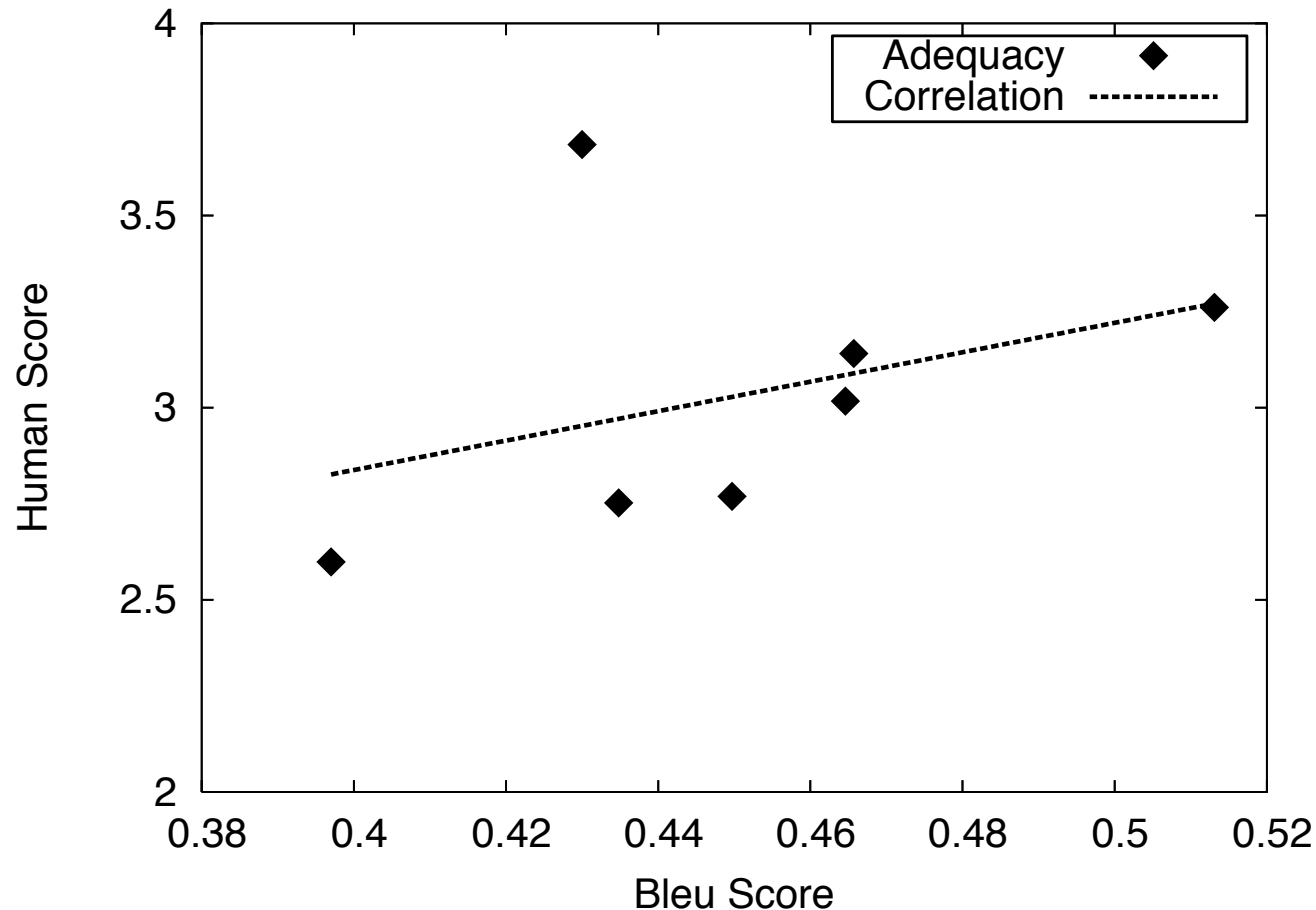
$$\text{variance } s_x^2 = \frac{1}{n - 1} \sum_{i=1}^n (x_i - \bar{x})^2$$

- Active development of new metrics
 - syntactic similarity
 - semantic equivalence or entailment
 - metrics targeted at reordering
 - trainable metrics
 - etc.
- Evaluation campaigns that rank metrics (using Pearson's correlation coefficient)

Evidence of Shortcomings of Automatic Metrics



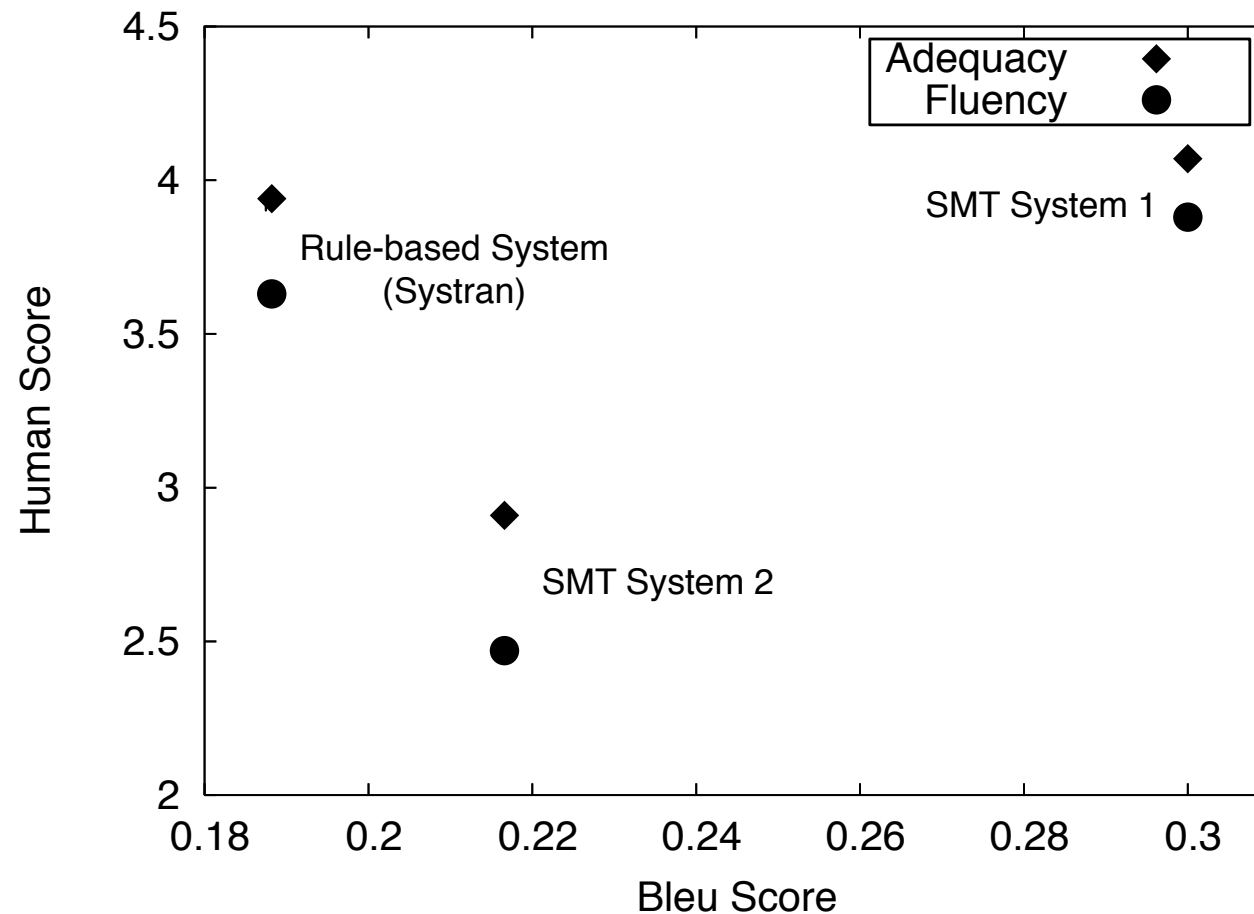
Post-edited output vs. statistical systems (NIST 2005)



Evidence of Shortcomings of Automatic Metrics



Rule-based vs. statistical systems



Automatic Metrics: Conclusions

- Automatic metrics essential tool for system development
- Not fully suited to rank systems of different types
- Evaluation metrics still open challenge

other evaluation methods

- Machine translations is a means to an end
- Does machine translation output help accomplish a task?
- Example tasks
 - producing high-quality translations post-editing machine translation
 - information gathering from foreign language sources

- Measuring time spent on producing translations
 - baseline: translation from scratch
 - post-editing machine translation

But: time consuming, depend on skills of translator and post-editor
- Metrics inspired by this task
 - TER: based on number of editing steps
Levenshtein operations (insertion, deletion, substitution) plus movement
 - HTER: manually construct reference translation for output, apply TER
(very time consuming, used in DARPA GALE program 2005-2011)

- Given machine translation output, can monolingual target side speaker answer questions about it?
 1. basic facts: who? where? when? names, numbers, and dates
 2. actors and events: relationships, temporal and causal order
 3. nuance and author intent: emphasis and subtext
- Very hard to devise questions
- Sentence editing task (WMT 2009–2010)
 - person A edits the translation to make it fluent (with no access to source or reference)
 - person B checks if edit is correct
 - did person A **understand** the translation correctly?

Other evaluation metrics

- **BLEU:** Bilingual Evaluation Understudy
- **ROUGE:** (Recall-Oriented Understudy for Gisting Evaluation)
- **METEOR:** (Metric for Evaluation of Translation with Explicit ORdering)

Other MT evaluation metrics

- **BLEU (Bilingual Evaluation Understudy)**
 - A score for evaluating the performance of a MT.
 - BLEU score compares automatically translated sentences (hypothesis) with one or more reference translations.
- **ROUGE (Recall-Oriented Understudy for Gisting Evaluation)**
 - Usually used for evaluating the quality of text summaries.
 - ROUGE compares word sequences, word pairs, and n-grams with a set of reference summaries created by humans.
 - Many ROUGE variants such as
 - **ROUGE-N** (Overlap of N-grams between the system and reference summaries)
 - **ROUGE-L** (Longest Common Subsequence (LCS) based statistics)
 - **ROUGE-W** (Weighted LCS-based statistics that favors consecutive LCSes)
 - **ROUGE-S** (Skip-bigram based co-occurrence statistics)
 - **ROUGE-SU** (Skip-bigram plus unigram-based co-occurrence statistics).
- **METEOR (Metric for Evaluation of Translation with Explicit ORdering)**
 - METEOR or is another metric used to evaluate the performance of a MT model.
 - METEOR compares Standard word segments with the reference texts. Stems and synonyms are also considered for matching.