# A Generate and Rank Approach to Sentence Paraphrasing

*Prodromos Malakasiotis[*]*
*Ion Androutsopoulos[*†]*

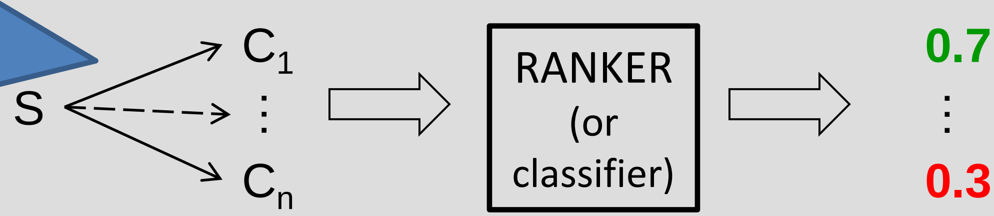
[*] NLP Group, Department of Informatics,
Athens University of Economics and Business, Greece
[†]Digital Curation Unit – IMIS,
Research Centre “Athena”, Greece

# Paraphrases

- Phrases, sentences, or longer expressions, or patterns with the **same** or **very similar meanings**.
  - "X is the writer of Y" ≈ "X wrote Y" ≈ "X is the author of Y".
  - Can be seen as **bidirectional textual entailment**.
- Paraphrase **recognition**:
  - Decide if **two given expressions** are paraphrases.
- Paraphrase **extraction**:
  - **Extract pairs** of paraphrases (or patterns) from a **corpus**.
  - **Paraphrasing rules** ("X is the writer of Y" ↔ "X wrote Y").
- Paraphrase **generation** (this paper):
  - Generate **paraphrases** of a **given phrase** or **sentence**.

# Generate-and-rank with rules

**Paraphrasing rules** rewrite the source in different ways producing **candidate paraphrases**.

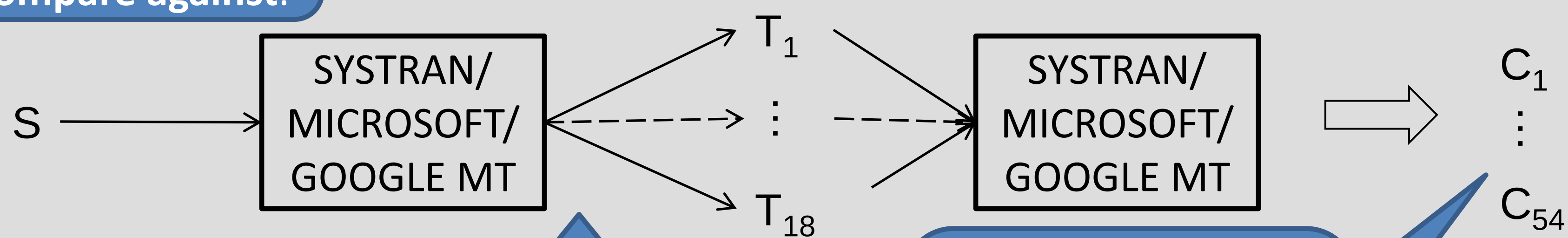



Our system.

We **focus** mostly on the **ranker**.
(We use an existing collection of rules. )

# Multi-pivot approach (Zhao et al. '10)

**State of the art** paraphraser we **compare against**.




3 MT engines, 6 pivot languages.

Pick the candidate(s) with the **smallest sum**(s) **of distances** from all other candidates and S.

# Applying paraphrasing rules

$R_1$: a lot of $NN_1$ ↔ plenty of $NN_1$

$S_1$: He had a lot of admiration for his job.
$NN_1$

$C_{11}$: He had plenty of admiration for his job.
$NN_1$

- We use approx. **1,000,000 existing paraphrasing rules** extracted from parallel corpora by Zhao et al. (2009).
  - Each rule has **3 context-insensitive scores** ($r_1$, $r_2$, $r_3$) indicating how good the rule is in general (see the paper for details).
  - We also use the **average** ($r_4$) of the three scores.
- For each source (S), we produce candidates (C) by using the **20 applicable rules** with the **highest average scores** ($r_4$).
  - Multiple rules may apply in parallel to the same S. We allow all possible rule combinations.

# Context is important

- Although we **apply** the **rules** with the **highest context-insensitive scores** ($r_4$), the **candidates may not be good**.
  - The **context-insensitive scores** are **not enough**.
- A paraphrasing rule may not be good in all **contexts**.
  - “X acquired Y” ↔ “X bought Y” (Szpektor 2008)
    - “IBM acquired Coremetrics” ≈ “IBM bought Coremetrics”
    - “My son acquired English quickly” ≠ “My son bought English quickly”
  - “X charged Y with” ↔ “X accused Y of”
    - “The officer charged John with…” ≈ “The officer accused John of…”
    - “Mary charged the batteries with…”≠ “Mary accused the batteries of…”

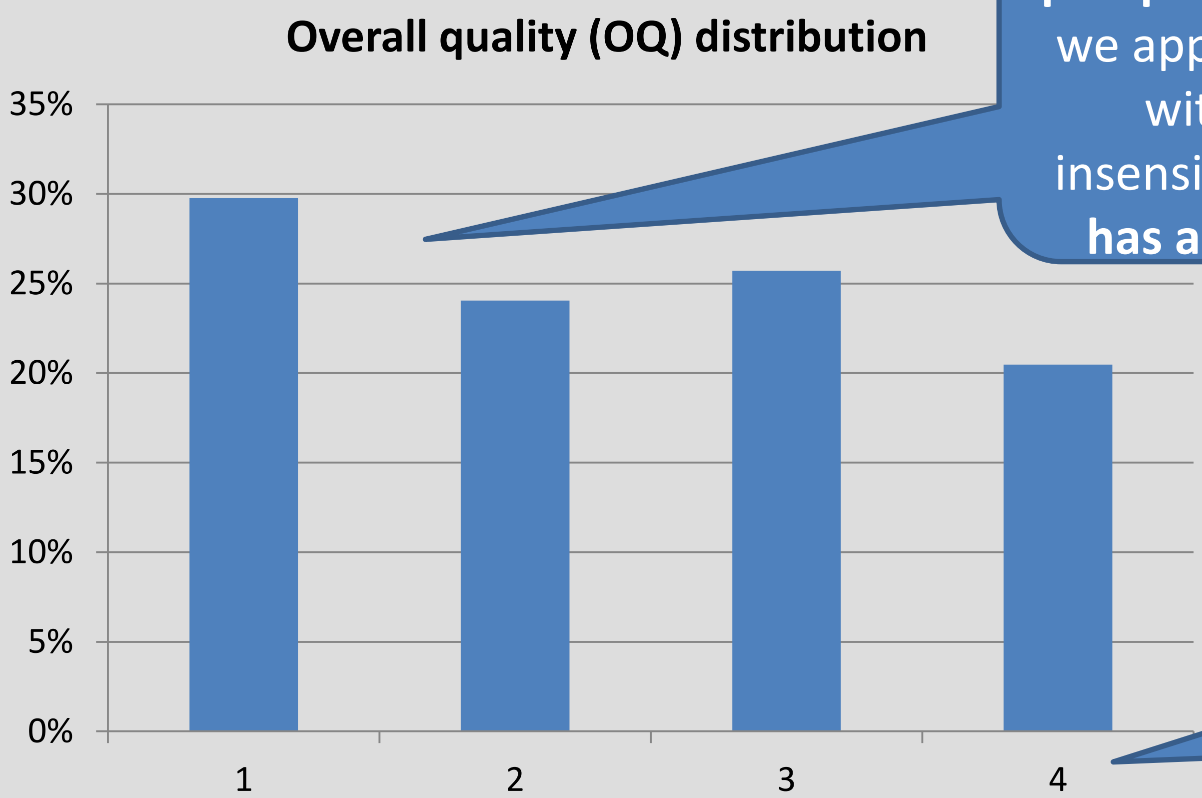
# Our publicly available dataset

- Intended to help **train and test alternative rankers** of generate-and-rank paraphrase generators.
- **75 source sentences (S)** from AQUAINT.
- **All candidate paraphrases (C)** of the 75 sources generated, by applying the rules with the best 20 context-insensitive scores ($r_4$).
- **Test data: 13 judges** scored (1 – 4 scale) the resulting **1,935 <S, C> pairs** in terms of:
  - **grammaticality** (GR),
  - **meaning preservation** (MP),
  - **overall quality** (OQ).

Reasonable **inter-annotator agreement** (see paper).

- **Training data**: another 1,500 <S, C> pairs scored by the **first author** in the same way (GR, MP, OQ).

# Overall quality (OQ) distribution in test data




**More than 50% of the candidate paraphrases judged bad**, although we apply only the "best" 20 rules with the highest context-insensitive scores ($r_4$). **The ranker has an important role to play!**

4: perfect
1: totally unacceptable

# Can we do better than just using the context-insensitive rule scores?

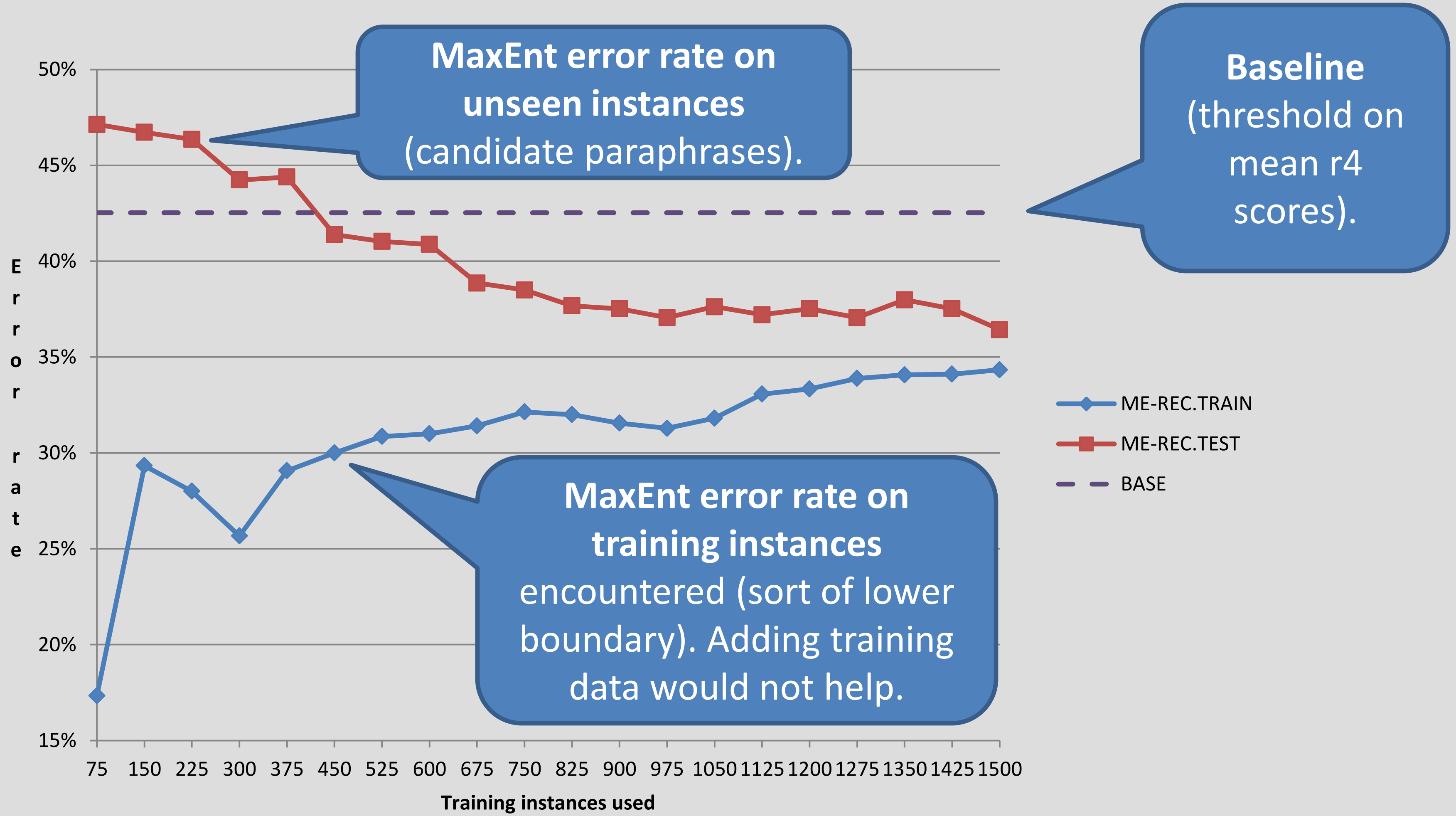
- In a **first experiment**, we used **only** the judges' **overall quality scores** (OQ).
  - **Negative class**: OQ 1-2. **Positive class**: OQ 3-4.
  - Task: **predict the correct class** of each <S, C> pair.
- **Baseline**: classify each <S, C> pair as positive iff the $\mathbf{r_4}$ **score** of the **rule** (or the mean $r_4$ score of the rules) that turned S into C is **greater than *t***.
  - The threshold *t* was tuned on held-out data.
- Against a **MaxEnt classifier** with 151 features.

# The 151 features

**All features normalized in [-1, +1].**

- **3 language model** features:
  - **Language model score** of the **source** (S), of the **candidate** (C), and their **difference**.
  - **3-gram LM** trained on ~6.5 million AQUAINT sentences.
- **12 features** for **context-insensitive rule scores**.
  - 3 for the **highest**, **lowest**, **mean** $\mathbf{r_4}$ scores of the rules that turned S to C. Similarly for $\mathbf{r_1}$, $\mathbf{r_2}$, $\mathbf{r_3}$.
- **136 features** of our **recognizer** (Malakasiotis 2009).
  - Multiple **string similarity measures** applied to original <S,C>, stemmed, POS-tags, Soundex… (see the paper).
  - Similarity of **dependency trees**, **length ratio**, **negation**, WordNet **synonyms**, …
  - **Best published results** on the **MSR paraphrase recognition corpus** (with full feature set, despite redundancy).

# MaxEnt beats the baseline



# Using an SVR instead of MaxEnt

- Some **judges said** they were **unsure how much** the **OQ scores** should reflect **grammaticality** (GR) or **meaning preservation** (MP).
- And that we should also consider **how different** (DIV, **diversity**) each candidate paraphrase (C) is from the source (S).
- **Instead of** (classes of) **OQ scores**, we now use:

  $$\boldsymbol{y} = \boldsymbol{\lambda_1} \cdot \mathbf{GR} + \boldsymbol{\lambda_2} \cdot \mathbf{MP} + \boldsymbol{\lambda_3} \cdot \mathbf{DIV}, \text{ with } \lambda_1 + \lambda_2 + \lambda_3 = 1.$$

  as the **correct score** of each <S, C> pair.
  - **GR** and **MP**: obtained from the **judges**.
  - **DIV**: **automatically** measured as **edit distance** on tokens.
- **SVRs** similar to SVMs, but for **regression**. Trained on examples $\langle \vec{\boldsymbol{x}}, \boldsymbol{y} \rangle$, $\vec{\boldsymbol{x}}$ is a **feature vector**, and $\boldsymbol{y} \in \mathbb{R}$ is the **correct score** for $\vec{x}$.
  - In our case, **each** $\vec{\boldsymbol{x}}$ represents an **<S, C> pair**.
  - The SVR **tries to guess the correct score** $\boldsymbol{y}$ of the <S, C> pair.
  - RBF kernel, **same features** as in MaxEnt.

# Which values of $\lambda_1, \lambda_2, \lambda_3$?

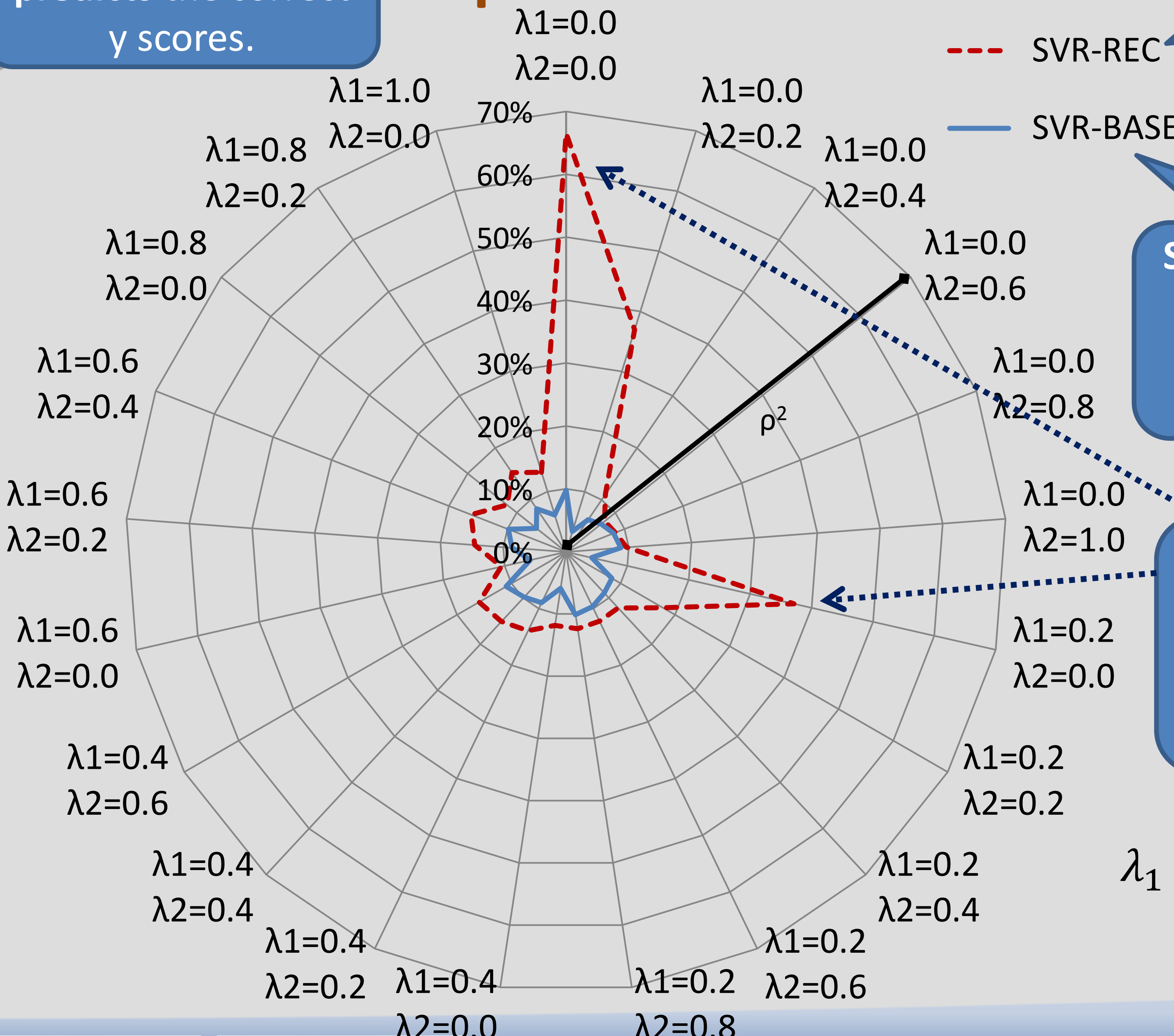
- By **changing** the **values of $\lambda_1, \lambda_2, \lambda_3$**, we can force our system to assign **more/less importance** to **grammaticality**, **meaning preservation**, **diversity**.
  - E.g., in **query expansion** for IR, **diversity** may be more **important** than grammaticality and (to some extent) meaning preservation.
  - In **NLG**, **grammaticality** is much more **important**.
  - The **$\lambda_1, \lambda_2, \lambda_3$** values **depend** on the **application**.
- A **ranker dominates** another one iff it performs **better for all combinations of $\lambda_1, \lambda_2, \lambda_3$ values**, i.e., in all applications.
  - Similar to comparing **precision/recall or ROC curves** in text classification.

# $\rho^2$ scores

**How well a ranker predicts** the correct y scores.

**SVR-REC ranker (151 features)**: also uses our recognizer's features.

**SVR-BASE (15 features):** LM features, features for context-insensitive rule scores.




When $\lambda_3$ is very high, we care only about **diversity**, and **SVR-REC includes features** measuring **diversity**.

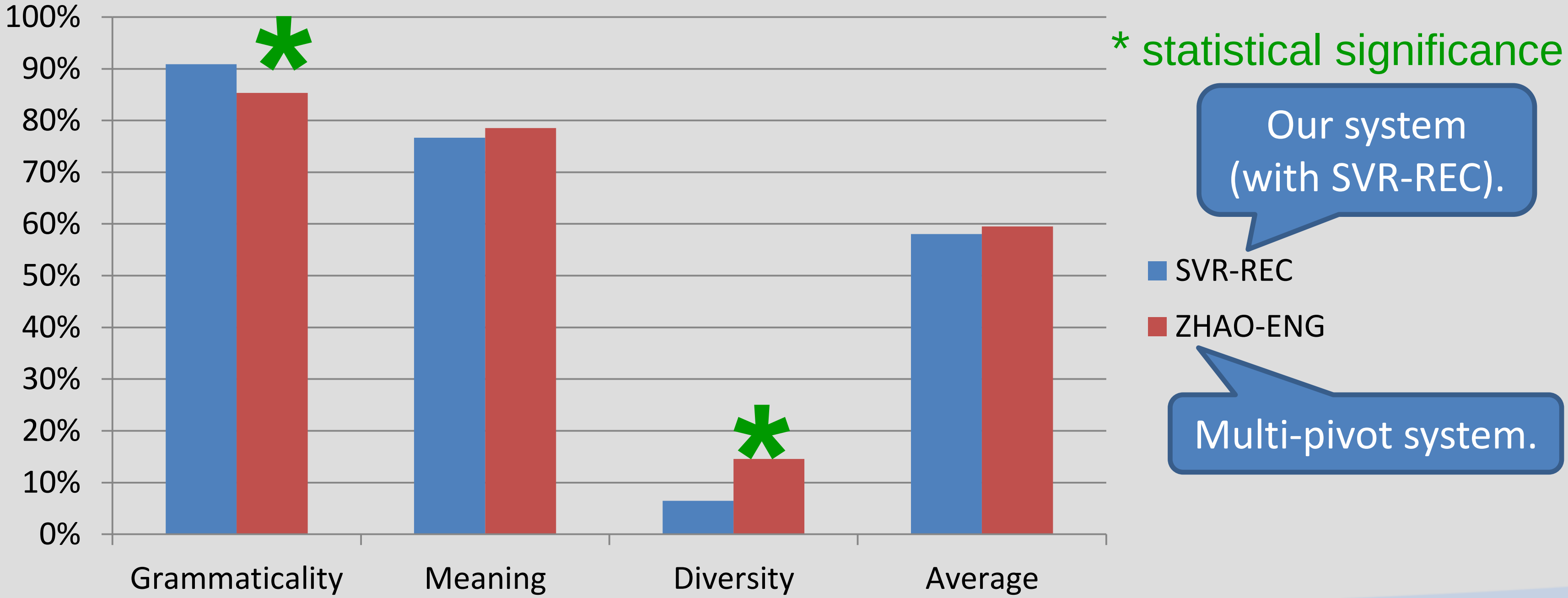
$$\lambda_1 + \lambda_2 + \lambda_3 = 1$$

# Comparing to the state of the art

- We finally compared **our system** (with **SVR-REC**) **against** Zhao et al.'s (2010) **multi-pivot approach**.
  - Multi-pivot approach re-implemented.
- The **multi-pivot** system **always generates paraphrases**.
  - Vast resources (3 commercial MT engines, 6 pivot languages).
- **Our system often** generates **no candidates**.
  - **No paraphrasing rule applies** to **~40%** of the sentences in the NYT part of AQUAINT.
- But **how good are the paraphrases**, when both systems produce at least one paraphrase?
  - **Simulating** the case where **more rules** have been added to our system, to the extent that **a rule always applies**.

# Comparing to the state of the art

- **300 new source sentences** (S) to which **at least one rule applied**:
  - **Top-ranked paraphrase** ($C_1$) of **our system** (**$\lambda_1 = \lambda_2 = \lambda_3 = 1/3$**).
  - **Top-ranked paraphrase** ($C_2$) of **multi-pivot** system (ZHAO-ENG).
  - Asked **10 judges** to score the <S, $C_1$>, <S, $C_2$> for **GR** and **MP**; **DIV measured automatically** as edit distance.




Athens University of Economics and Business

INFORMATICS DEPARTMENT

AUEB Natural Language Processing Group

http://nlp.cs.aueb.gr/

# Conclusions

- A new **generate-and-rank** method to **paraphrase sentences**.
  - Existing **paraphrasing rules** generate candidate paraphrases, and an **SVR ranker** (or MaxEnt) selects the best.
  - Can be **tuned** to assign **more/less importance** to **grammaticality**, **meaning preservation**, **diversity**
  - **Performs well against state-of-the-art** multi-pivot paraphraser, **when paraphrasing rules apply**.
- A new **methodology** and **publicly available dataset** to **evaluate different ranking components** of generate-and-rank paraphrasers.
  - Across **different combinations of weights** for **grammaticality**, **meaning preservation**, **diversity**.

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# Future work

- **Compare** to the **multi-pivot** approach for **more combinations** of **$\lambda_1$, $\lambda_2$, $\lambda_3$ values**.
  - Instead of only $\lambda_1 = \lambda_2 = \lambda_3 = 1/3$.
- Add **more paraphrasing rules**.
  - To be able to **paraphrase more source sentences**.
- **Combine** the **multi-pivot** approach and our **SVR ranker**.
  - **Generate candidates** with **both paraphrasing rules** and as in the **multi-pivot approach**.
  - Rank them with (a version of) our **SVR ranker**.
- **Use paraphrase generation** in **larger systems** (IR, QA, NLG) and in **sentence compression**.
  - See our **UCNLG+Eval paper** on sentence compression.