Alignment-Based Discriminative String Similarity

Shane Bergsma and Greg Kondrak
University of Alberta

ACL 2007

String Similarity

- Input: Pair of Strings
- Output: Measure of Similarity
- Our approach: discriminative, data-driven
- Features are substrings extracted from a character-based alignment of the strings
- Evaluate on cognate identification
- Excellent results

Outline

1. String similarity and its applications
2. Previous approaches
3. Alignment-based discriminative similarity
4. Cognate Data Generation
5. Experiments and Results

1. String Similarity

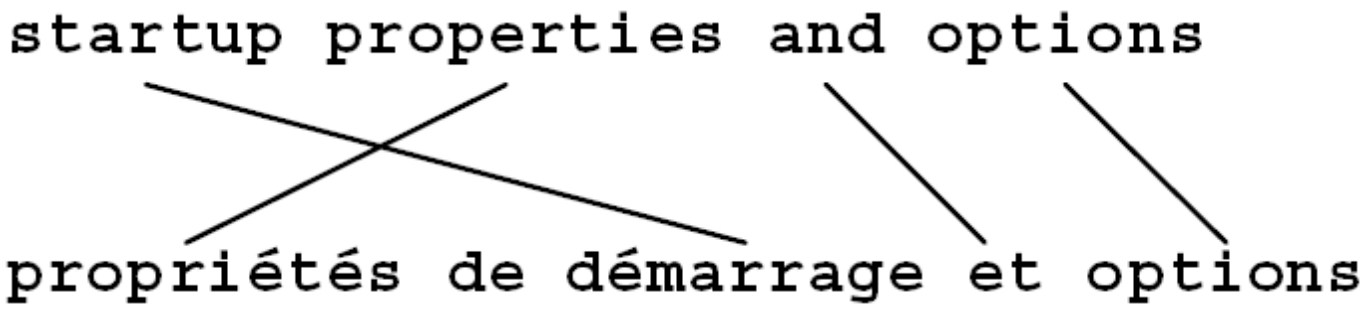
- Example: Spelling Correction:

Wallmart	Wall-mart
Britany Spears	Britney Spears
Amtrack	Amtrak
Hillary Duff	Hilary Duff
Geneology	Genealogy

(From Yahoo's most common search query spelling errors)

String Similarity

- Example: Word Alignment



- Words with similar form and meaning are called cognates:

propriétés	properties
options	options

Cognate Identification

- Cognates:
  - Ancestral: English/German *night/nacht*
  - Borrowed: English/Japanese *trampoline/toranporin*
- Our focus: “translational” cognates
- String similarity indicates how likely the two words are to be translations based on their orthographic similarity

2. Previous Approaches

Traditional Approaches:

- Normalized Edit Distance
- Longest Common Subsequence Ratio (LCSR)

  – Efficient, no training data needed, but not optimized for specific tasks

Improved Approaches

- Tiedemann (1999), Mulloni & Pekar (2006)
  - Look for consistent spelling changes across cognates: e.g. English/German *electric-elektrisch*
  - Re-weight LCSR/NED to add uncounted "mutations"

Klementiev and Roth (2006)

- Originally for Named-Entity Transliteration
- Discriminative String Similarity:
  - Extract features for pairs of strings: create feature vector
  - Label feature vectors as positive or negative
  - Train classifier on labelled feature vectors

Klementiev and Roth (2006)

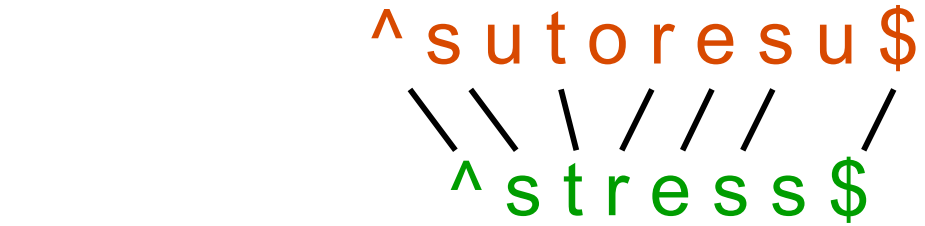
For Cognates:

- E.g: Japanese/English *sutoresu*:*stress*
- *sutoresu* → { `s, u, t, o, r, e, s, u, su, ut, …` }
- *stress* → { `s, t, r, e, s, s, st, tr, re, es, ss` }
- Gives features:

{*s-s, s-t, s-st, su-s, su-t, su-st, su-tr… r-s, r-s, r-es …*}

3. Alignment-Based Discriminative

- The character-based alignment generates the features for discriminative learning:



- Gives features:

{^-^, ^s-^s, s-s, su-s, ut-t, t-t, … es-es, s-s, su-ss … }

- Creates a more focused feature space for a given max substring size

Alignment-Based Discriminative

- Include other features like NED and special longer phrases
- Learn classifier with SVM, score by positive distance from SVM hyperplane.
  - See paper for more details

Outline

1. String similarity and its applications
2. Previous approaches
3. Alignment-based discriminative similarity
4. Cognate Data Generation
5. Experiments and Results

4. Cognate Data Generation

- Manual:
  - Get linguist (or computational linguist) to identify all cognates
- Automatic:
  - Define cognates to be all pairs with LCSR ≥ 0.58 that have the same meaning (Melamed, 1999).

Cognate Data Generation

- Determining common meaning:
  - Method 1:
    - Are they translations in a translation lexicon?
  - Method 2:
    - Are they commonly aligned in a word-aligned bitext?

Cognate Data Generation

- For a given foreign word *f*, find cognates among E_f that have LCSR ≥ 0.58
  - Examples:

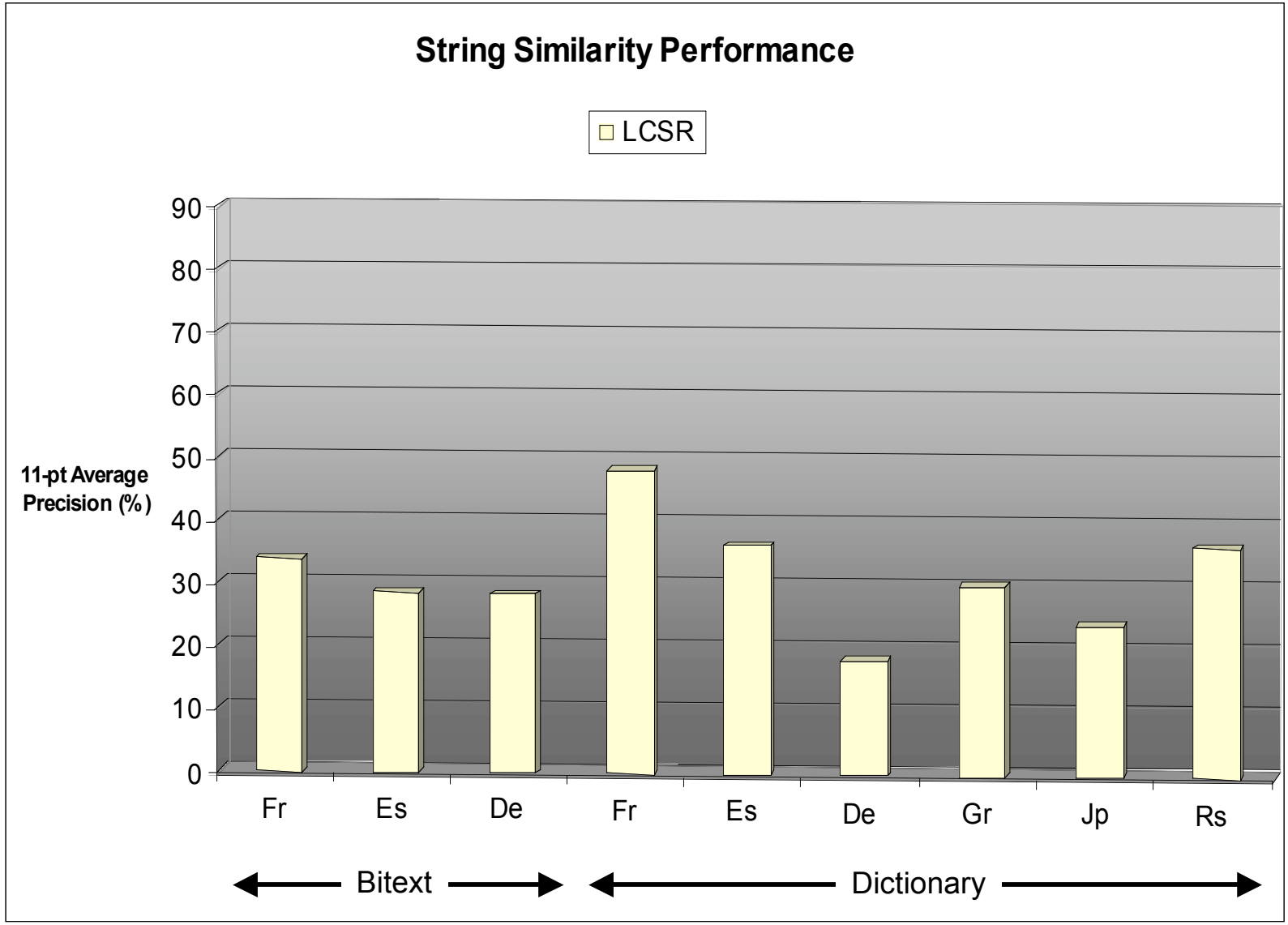
Language	Foreign word *f*	Cognates E_{f+}	False Friends E_{f-}
Japanese	napukin	napkin	nanking, pumpkin, snacking, sneaking
French	abondamment	abundantly	abandonment, abatement,… wonderment

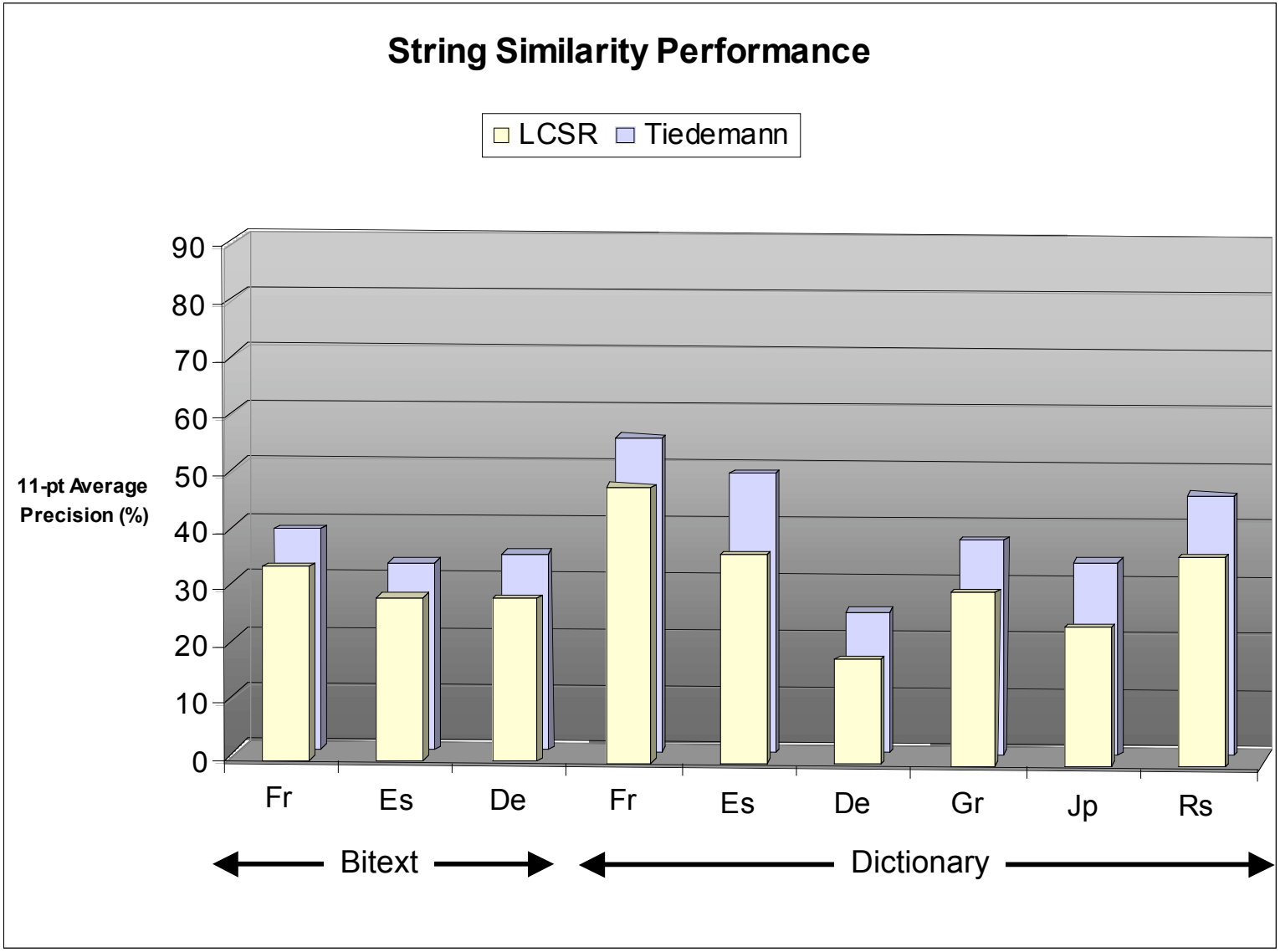
Cognate Data Generation

- Not a ranking task – not every foreign word has a cognate
- Rather, a *pairwise* classification:
  + napukin, napkin
  - napukin, nanking
  - napukin, pumpkin
- Note: automatically creates competitive counter-examples for learning

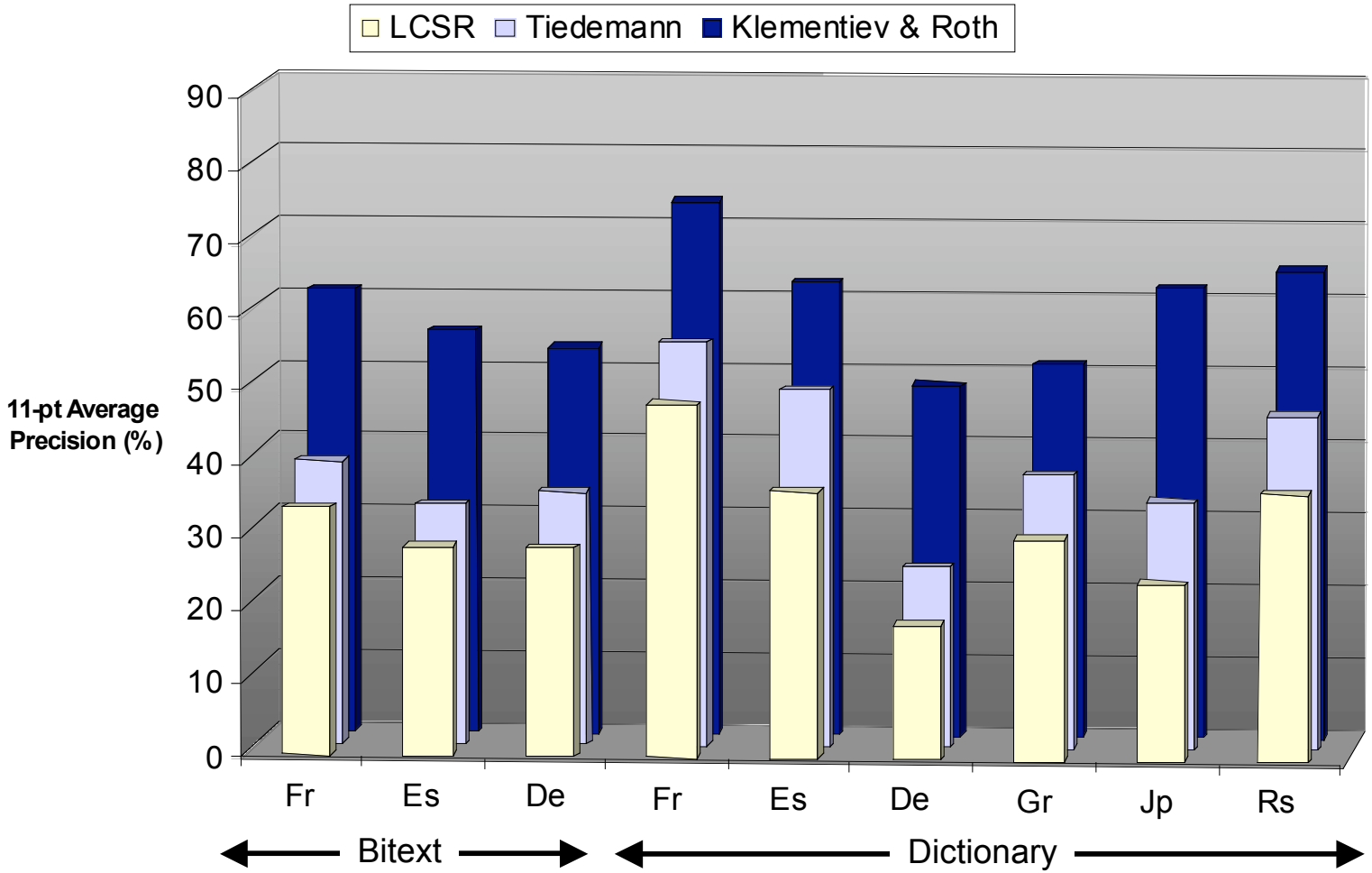
5. Experiments and Results

1) Bitext Experiments
   - French-English, Spanish-English, German-English
   - Word-aligned data from the Europarl corpus
2) Dictionary Experiments
   - Word pairs from www.Freelang.net
   - French-English, Spanish-English, German-English, Greek-English, Japanese-English, Russian-English
   - Romanization of Greek, Russian

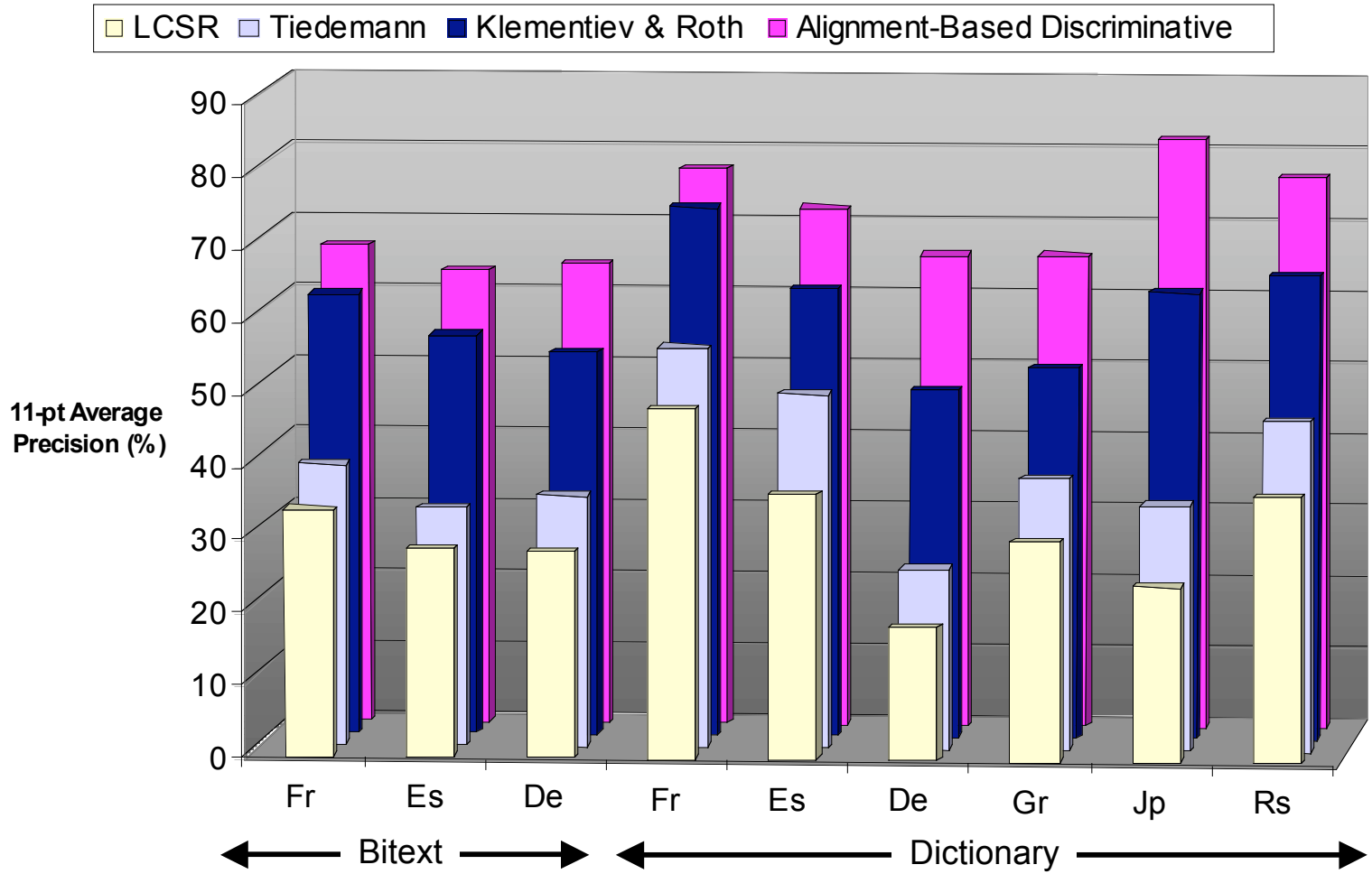

String Similarity Performance
LCSR
11-pt Average Precision (%)
90
80
70
60
50
40
30
20
10
0
Fr
Es
De
Fr
Es
De
Gr
Jp
Rs
Bitext
Dictionary


String Similarity Performance
LCSR
Tiedemann
11-pt Average Precision (%)
90
80
70
60
50
40
30
20
10
0
Fr
Es
De
Fr
Es
De
Gr
Jp
Rs
Bitext
Dictionary

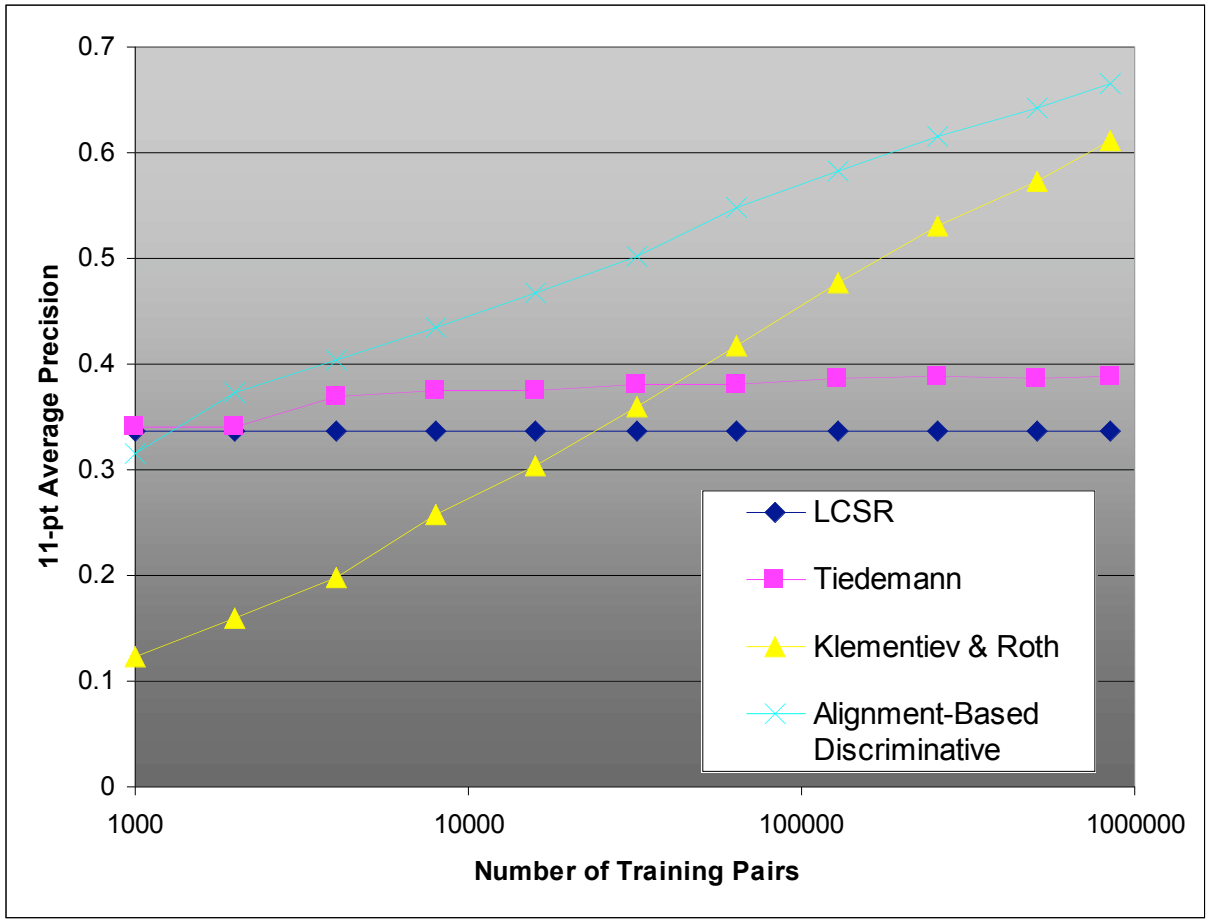
String Similarity Performance



String Similarity Performance



Bitext Fr-En Learning Curve



Important Features

Language	Feature	Weight	Example
French	ées-ed	+8.0	vérifiées:verified
German	k-c	+5.5	kreativ:creative
Greek	f-ph	+4.1	symfonia:symphony
Japanese	ou-ou	-2.6	handoutai:handout*
Spanish	mos-s	-5.1	toleramos:tolerates*

Conclusion

- First approach to apply discriminative string similarity to cognate identification
- Alignment-based features allow for strong gains in performance
- Phonetic, syntactic or semantic features can be incorporated into this framework

Thanks

String Similarity

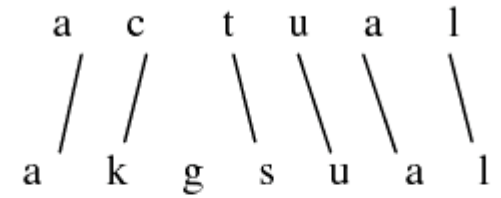
- Example: Named Entity Transliteration:

English NE	Russian NE
lilic	лилич
fletcher	флетчер
bradford	брэдфорд
isabel	изабель
hoffmann	гофман
kathmandu	катманду

(From Klementiev & Roth (2006))

Brill and Moore (2000)

- Get probability of edit operations for spelling correction
- Expand non-match substitutions with adjacent edits
- Learn generative model with EM



a→a c→k ε→g t→s u→u a→a l→l

c → k
ac → ak
c → kg
ac → akg
ct → kgs

Other Features

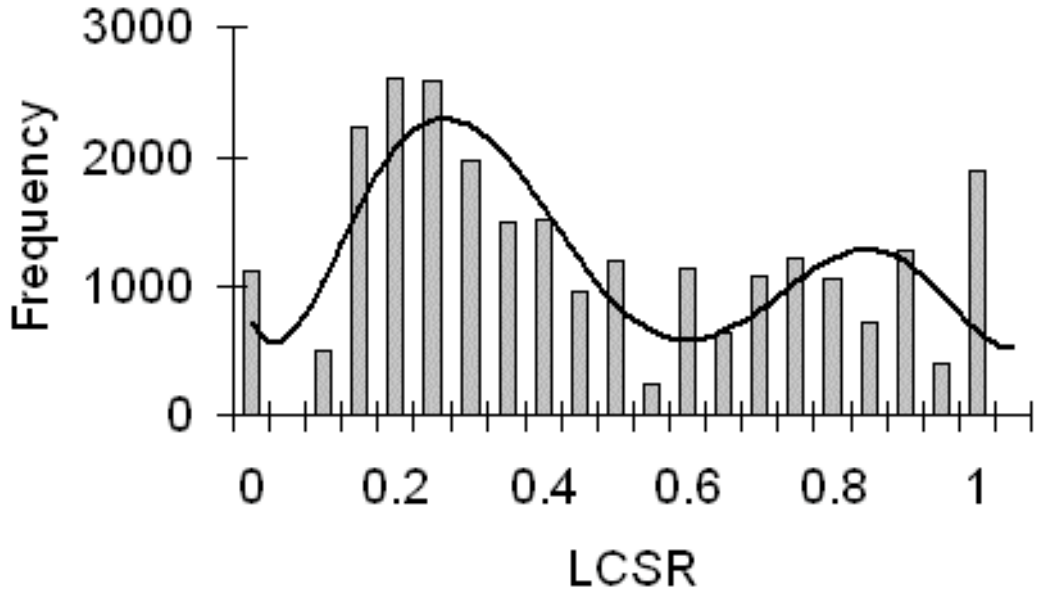
- Issues:
  - to learn: "*economic*" – "*économique*"
  - has ending mutation: "*ic$*" – "*ique$*"
  - requires a length-5 substring
- Solution:
  - Include all (arbitrary-length) substrings with aligned end characters, mismatching middles
- Also: Include NED as a feature

Learning Approach

- Support Vector Machine, linear kernel
  - optimize regularization parameter on dev. set
  - score pairs by positive distance from SVM hyperplane

Cognate Data Generation

- Is LCSR ≥ 0.58 a good working definition of cognation? French-English Dictionary:



System Development

System	Prec
Klementiev-Roth (KR) L≤2	58.6
KR L≤2 (normalized, boundary markers)	62.9
phrases L≤2	61.0
phrases L≤3	65.1
phrases L≤3 + *mismatches*	65.6
phrases L≤3 + *mismatches* + NED	**65.8**

Table 2: Bitext French-English *development set* cognate identification 11-pt average precision (%).

Example Most-Similar Words

Greek-English – Dictionary	Spanish-Engilish - Bitext
alkali:alkali	agenda:agenda
makaroni:macaroni*	natural:natural
adrenalini:adrenaline	márgenes:margins
flamingko:flamingo	hormonal:hormonal
spasmodikos:spasmodic	radón:radon
amvrosia:ambrosia	higiénico:hygenic

Other Approaches

- Ristad & Yanilos (1999)
  - stochastic transducer version of Edit Distance
  - can work with string pairs from different alphabets
- CRFs – learn to align as well as calculate similarity