



PASCAL

Pattern Analysis, Statistical Modelling and
Computational Learning



Introduction to Morpho Challenge 2009

Mikko Kurimo, Sami Virpioja, Ville Turunen
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Opening

Welcome to the Morpho Challenge 2008
workshop:

- challenge participants
- workshop speakers
- other CLEF researchers
- everybody who is interested in the topic!



→ **09:10 Mikko Kurimo:** Introduction

09:20 Mikko Kurimo: Competition 1 -
Comparison to Linguistic Morphemes

09:40 Ville Turunen: Competition 2 -
Information Retrieval

09:55 Sami Virpioja: Competition 3 -
Statistical Machine Translation

10:10 Sami Virpioja: Unsupervised
Morpheme Discovery with
Allomorfessor

10:25 Burcu Can: Unsupervised Learning
of Morphology by using Syntactic
Categories

10:40 Sebastian Spiegler: PROMODES:
A probabilistic generative model for
word decomposition

10:55 Sebastian Spiegler (Golenia):
UNGRADE: UNsupervised GRAph
DEcomposition

11:10 break

11:20 Jean-François Lavallée:
Morphological acquisition by Formal
Analogy

11:35 Constantine Lignos: A Rule-
Based Unsupervised Morphology
Learning Framework

11:50 Christian Monson:
Probabilistic ParaMor

**12:05 Christian Monson
(Tchoukalov):** Multiple Sequence
Alignment for Morphology Inductiity"

12:10 Discussion

13:00 Conclusion



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Morpho Challenge

- Part of the EU Network of Excellence PASCAL
- Organized in collaboration with CLEF
- Participation is *open to all and free of charge*
- Data provided in: *Finnish, English, German, Turkish and Arabic*
- **Task:** Implement an unsupervised algorithm that discovers *morpheme analysis of words in each language!*



Contents

- 1. Goal of Morpho Challenge
- 2. Unsupervised word segmentation
- 3. History of Morpho Challenge
- 4. Tasks and evaluations 2009
- 5. Future of Morpho Challenge



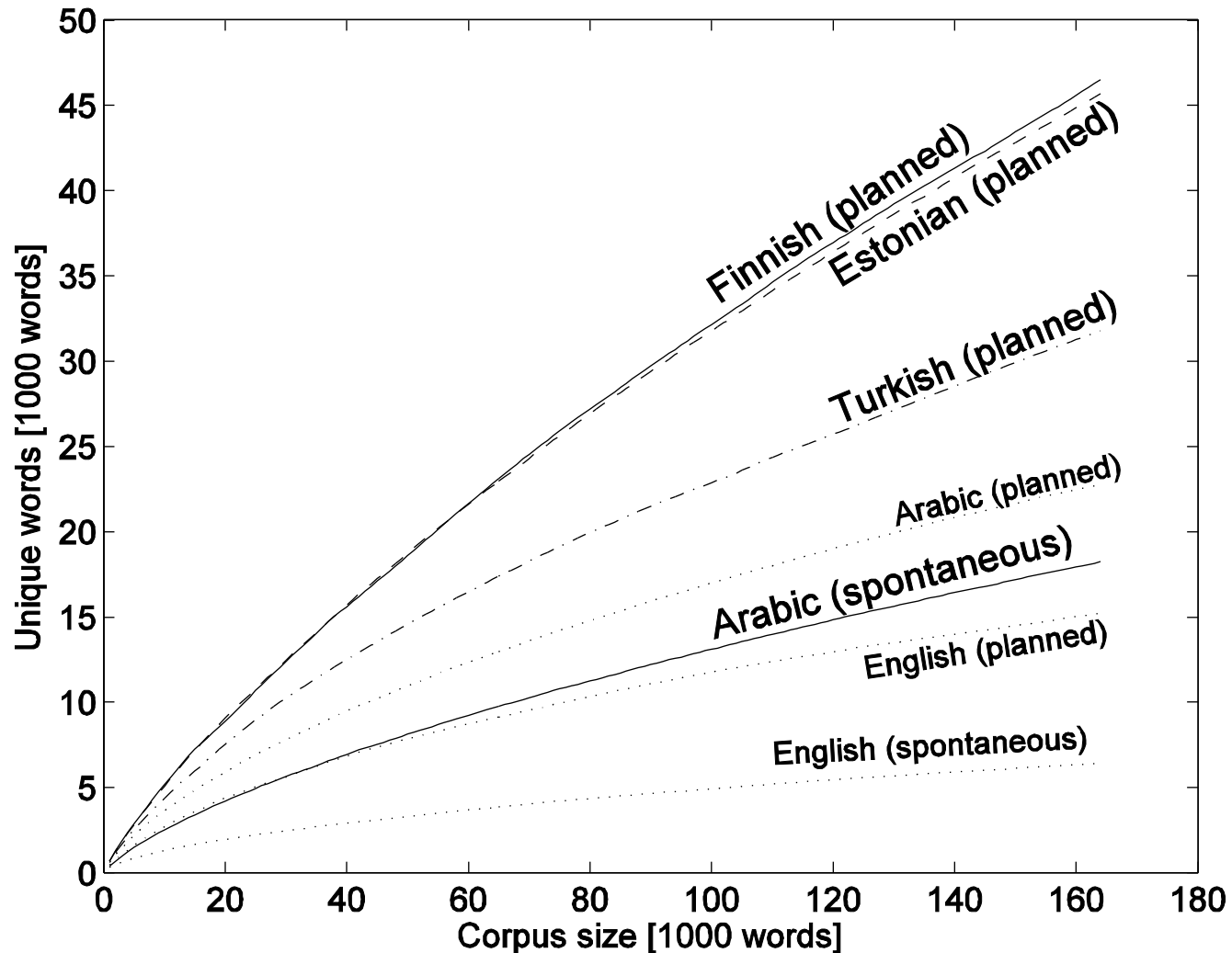
Goals of the project

- Design statistical machine learning algorithms that **discover** which **morphemes** words consist of
- Find morphemes that are useful as **vocabulary units** for statistical language modeling in: *Speech recognition, Machine translation, Information retrieval*
- Discover approaches suitable for a **wide range of languages and tasks**



The vocabulary problem

- ASR, IR and SMT require a **large vocabulary**
- **Agglutinative and highly-inflected** languages suffer from a severe **vocabulary explosion**
- More efficient representation units needed





Agglutinative morphology

- Finnish words typically consist of lengthy sequences of morphemes — **stems**, **suffixes** (and sometimes **prefixes**):
 - **kahvi + n + juo + ja + lle + kin** (*coffee + of + drink + -er + for + also = 'also for [the] coffee drinker'*)
 - **nyky + ratkaisu + i + sta + mme** (*current + solution + -s + from + our = 'from our current solutions'*)
 - **tietä + isi + mme + kö + hän** (*know + would + we + INTERR + indeed = 'would we really know?'*)
 - **tietä + vä + mmä + lle** (*know + -ing + COMP + for = 'for the more knowing' = 'for the one who knows more'*)



Morfessor

- Automatic segmentation of words into morphemes
- A fully data-driven unsupervised machine learning algorithm
- Discovers a compact representation of the input text corpus
- MAP optimization where the result resembles linguistic morphemes: **left + hand + ed**, **hand + ful**
- Language independent, no morphological rules or annotated data needed
- Toolkit available at <http://www.cis.hut.fi/projects/morpho/>
[PhD thesis of M. Creutz (2006)]



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History of Morpho Challenge

- Submissions:
 - 2005: words split into smaller units
 - 2007-2009: full morpheme analysis of words
- Evaluation tasks:
 - 2005: linguistic & speech recognition
 - 2007-2008: linguistic & information retrieval
 - 2009: +machine translation



History of Morpho Challenge

- Evaluation languages:
 - 2005: Finnish, Turkish, English
 - 2007: + German
 - 2008 - 2009: + Arabic
- Participating groups:
 - 2005: 4 (+ 7 students groups)
 - 2007: 6
 - 2008: 6
 - 2009: 10



2009 Challenge

- The participants submit their morpheme analyses
- The organizers evaluate them in various ways:
 1. Comparison to a *linguistic* morpheme "gold standard"
 2. *Information retrieval* experiments, where the indexing is based on morphemes instead of entire words
 3. *Machine translation* experiments, where the translation is based on morphemes



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Future directions

- New languages: Russian, Indian languages,...
- New tasks: QA, word alignment, speech synthesis...
- New workshops: Venice, Budapest, Aarhus, Corfu, ...
- New supporters: PASCAL, CLEF, EMIME, ...
- New participants!
- New and improved learning algorithms!



More info of Morpho Challenge

- Data, references, previous results:
- <http://www.cis.hut.fi/morphochallenge2009/>
- Email *Mikko.Kurimo @ tkk.fi* to join the mailing list
- Information of the Morpho Challenge **2010** will become available within the next two months



Thanks

Thanks to all who made Morpho Challenge 2008 possible:

- PASCAL network, CLEF, Leipzig corpora collection, Univ. Leeds, Univ. Haifa
- Gold standard providers: Majdi Sawalha, Eric Atwell, Ebru Arisoy, Stefan Bordag and Mathias Creutz
- Morpho Challenge organizing committee, program committee and evaluation team
- Morpho Challenge participants
- CLEF 2009 workshop organizers



Discussion topics for the end

- New ways to evaluate morphemes ?
- Use context for more accurate gold standard and evaluation, also in IR ?
- New test languages: Hungarian, Estonian, Russian, Korean, Japanese, Chinese ?
- New application evaluations ?
- New organizing partners ?
- Next Morpho Challenge 2010 / 2011 ?
- Journal special issue ?
- Next Morpho Challenge workshop ?



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Competition 1

- **Goal:** Compare unsupervised morphemes to **grammatical morphemes** in a linguistic gold standard
- **Problem:** Unsupervised morphemes can have **arbitrary labels**
- **Solution:** Check if the **morpheme-sharing word pairs** are the same as in the gold standard
- **Evaluation:** Compute matches from a **large random sample** of word pairs where both words in the pair have a common morpheme



Available training data

- Downloadable texts and word frequency lists
- **Finnish**: 3M sentences, 2.2M word types
- **Turkish**: 1M sentences, 620K word types
- **German**: 3M sentences, 1.3M word types
- **English**: 3M sentences, 380K word types
- **Arabic**: 78K words, 12K word types
- Small sample of gold standard analyses in each language



Examples of gold standard analyses

- **English:** baby-sitters: baby_N sit_V er_s +PL
- **Finnish:** linuxiin: linux_N +ILL
- **Turkish:** kontrole: kontrol +DAT
- **German:** zurueckzubehalten:
zurueck_B zu be halt_V +INF
- **Arabic:** AlmtHdp: mut aHidap_POS:PN Al+ +SG



Evaluation measures

- $F\text{-measure} = 1 / (1 / \textit{Precision} + 1 / \textit{Recall})$
- *Precision* is the proportion of suggested word pairs that also have a morpheme in common according to the gold standard
- *Recall* is the proportion of word pairs *sampled from the gold standard* that also have a morpheme in common according to the suggested algorithm



Normalization of points

- **NEW:** A small change from 2007 and 2008
- One point is now given for each correct word (not for each word pair)
- Normalization affects words that have several morphemes or alternative analyses
- All morphemes of the word in all alternative analyses will get an equal weight
- From the alternative analyses, the best matching one is still chosen



Table 1: The participants and the names of their algorithms.

Author	Affiliation	Algorithm name
D. Bernhard	TU Darmstadt, D	MorphoNet
B. Can & S. Manandhar	Univ. York, UK	-
D. Currie & N. Rampersad*	Univ. Winnipeg, CA	Occam A
D. Currie & N. Rampersad*	Univ. Winnipeg, CA	Occam B
B. Golénia et al.	Univ. Bristol, UK	UNGRADE
J-F. Lavallée & P. Langlais	Univ. Montreal, CA	RALI-ANA
J-F. Lavallée & P. Langlais	Univ. Montreal, CA	RALI-COF
C. Lignos et al.	Univ. Pennsylvania & Arizona, USA	-
C. Monson et al.	Oregon Health & Science Univ., USA	ParaMor Mimic
C. Monson et al.	Oregon Health & Science Univ., USA	ParaMor-Morfessor Mimic
C. Monson et al.	Oregon Health & Science Univ., USA	ParaMor-Morfessor Union
S. Spiegler et al.	Univ. Bristol, UK	PROMODES
S. Spiegler et al.	Univ. Bristol, UK	PROMODES 2
S. Spiegler et al.	Univ. Bristol, UK	PROMODES committee
T. Tchoukalov et al.	Univ. Stanford & OHSU, USA	MetaMorph
S. Virpioja & O. Kohonen	Helsinki Univ. of Tech., FI	Allomorfessor

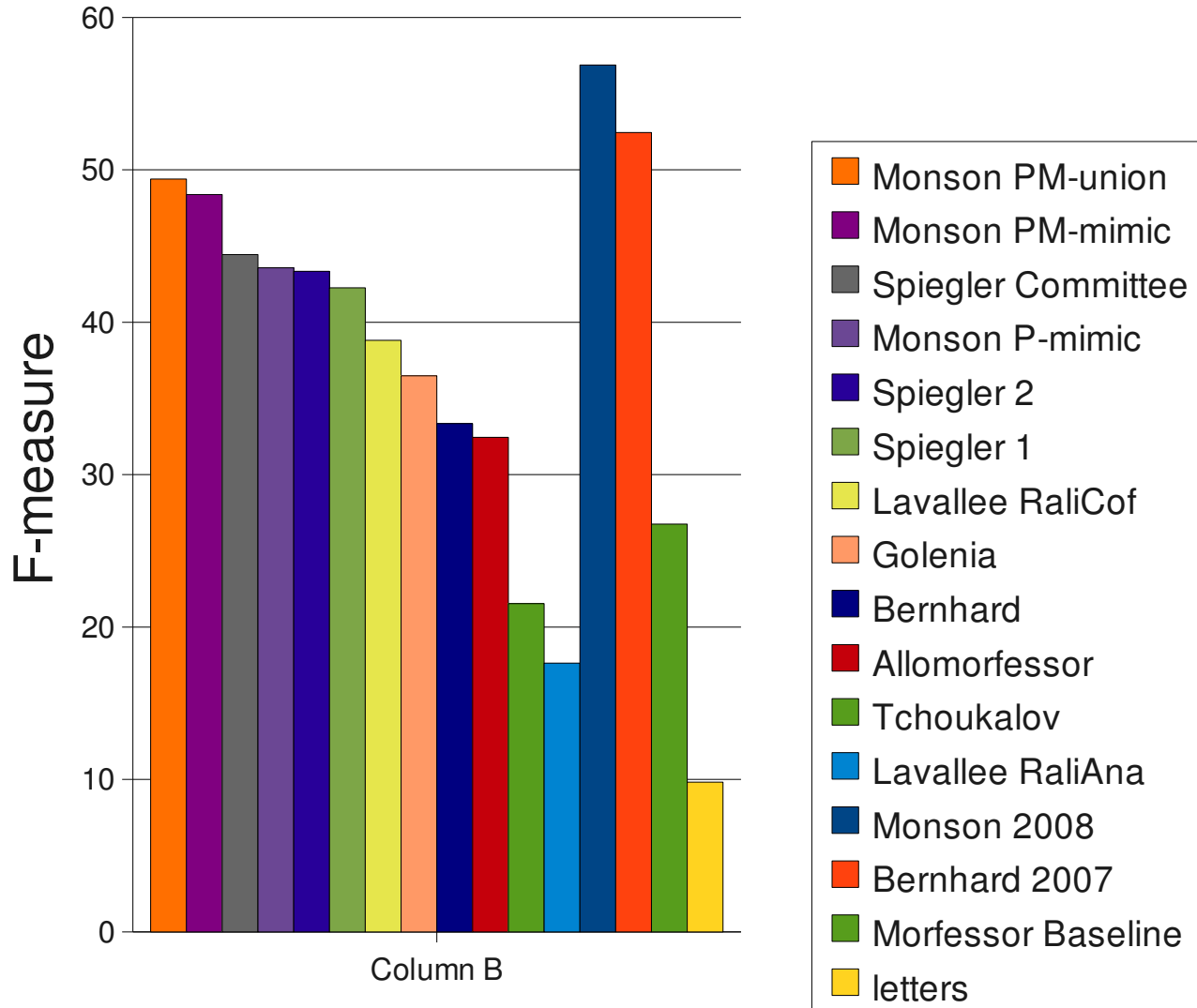
Table 5: English statistics.

Algorithm	#a	#m	lexicon	example analysis
Bernhard – MorphoNet	1	1.75	211439	vulnerabilty _ies
Can & Manandhar	1	2.09	150097	vulner abilities
Golénia et al. – UNGRADE	1	3.87	123634	vulnerabilities
Lavallée & Langlais – RALI-ANA	1	2.10	166826	vulner abiliti es
Lavallée & Langlais – RALI-COF	1	1.91	145733	vulnerability ies
Lignos et al.	1	1.74	198546	VULNERABILITY +(ies)
Monson et al. – ParaMor Mimic	1	3.03	188716	vulner +a +bilit +ie +s
Monson et al. – ParaMor-Morfessor Mimic	1	2.96	166310	vulner +a +bilit +ies
Monson et al. – ParaMor-Morfessor Union	1	2.87	120148	vulner a +bilit +ies
Spiegler et al. – PROMODES	1	3.28	107111	vul nerabilitie s
Spiegler et al. – PROMODES 2	1	3.63	47456	v ul nera b ili ties
Spiegler et al. – PROMODES committee	1	3.63	47456	v ul nera b ili ties
Tchoukalov et al. – MetaMorph	1	1.58	241013	vulnerabiliti es
Virpioja & Kohonen – Allomorfessor	1	2.59	23741	vulnerability ies
Morfessor Baseline	1	2.31	40293	vulner abilities
Morfessor CatMAP	1	2.12	132038	vulner abilities
letters	1	9.10	28	v u l n e r a b i l i t i e s
Gold Standard	1.06	2.49	18855	vulnerable_A ity_s +PL

Table 6: Finnish statistics.

Algorithm	#a	#m	lexicon	example analysis
Bernhard – MorphoNet	1	2.53	984581	eu-jäsenmaita _ss_ _- _s_ _ssa
Golénia et al. – UNGRADE	1	4.60	790814	eu jäse nmaiss a
Lavallée & Langlais – RALI-ANA	1	2.05	1217550	eu- jäsenmais s a
Lavallée & Langlais – RALI-COF	1	2.39	723171	jäsenmaissa eu-
Monson et al. – ParaMor Mimic	1	3.30	1149382	eu-jäsenma +i +ssa
Monson et al. – ParaMor-Morfessor Mimic	1	4.24	323561	eu- +jäsen ma +i +ssa
Monson et al. – ParaMor-Morfessor Union	1	4.02	215118	eu- +jäsen ma +i +ssa
Spiegler et al. – PROMODES	1	4.88	296010	e u jä sen mais sa
Spiegler et al. – PROMODES 2	1	5.64	97558	eu j äsen mais sa
Spiegler et al. – PROMODES committee	1	4.94	199700	e u j äsen maissa
Tchoukalov et al. – MetaMorph	1	1.87	2036496	eu- jäsenmaissa
Virpioja & Kohonen – Allomorffessor	1	2.46	70228	eu- jäsen maissa
Morfessor Baseline	1	2.21	149417	eu- jäsenmaissa
Morfessor CatMAP	1	2.94	217001	eu- jäsen maissa
letters	1	13.78	32	e u - j ä s e n m a i s s a
Gold Standard	1.16	3.52	41815	eu jäsen_N maa_N +PL +INE

Results: Finnish, 2.2M word types



Finnish (Competition 1).

Author	Method	Precision	Recall	F-measure
Monson et al.	ParaMor-Morfessor Union	47.89%	50.98%	49.39%
Monson et al.	ParaMor-Morfessor Mimic	51.75%	45.42%	48.38%
-	Morfessor CatMAP	79.01%	31.08%	44.61%
Spiegler et al.	PROMODES committee	41.20%	48.22%	44.44%
Monson et al.	ParaMor Mimic	47.15%	40.50%	43.57%
Spiegler et al.	PROMODES 2	33.51%	61.32%	43.34%
Spiegler et al.	PROMODES	35.86%	51.41%	42.25%
Lavallée & Langlais	RALI-COF	74.76%	26.20%	38.81%
Golénia et al.	UNGRADE	40.78%	33.02%	36.49%
Bernhard	MorphoNet	63.35%	22.62%	33.34%
Virpioja & Kohonen	Allomorfessor	86.51%	19.96%	32.44%
-	Morfessor Baseline	89.41%	15.73%	26.75%
Tchoukalov et al.	MetaMorph	37.17%	15.15%	21.53%
Lavallée & Langlais	RALI-ANA	60.06%	10.33%	17.63%
-	letters	5.17%	99.89%	9.83%
Monson et al. 2008	ParaMor + Morfessor	65.21%	50.43%	56.87%
Monson et al. 2008	ParaMor	49.97%	37.64%	42.93%
Bernhard 2007	2	63.92%	44.48%	52.45%

English (Competition 1).

Author	Method	Precision	Recall	F-measure
Virpioja & Kohonen	Allomorfessor	68.98%	56.82%	62.31%
-	Morfessor Baseline	74.93%	49.81%	59.84%
Monson et al.	ParaMor-Morfessor Union	55.68%	62.33%	58.82%
Lignos et al.	-	83.49%	45.00%	58.48%
Monson et al.	ParaMor Mimic	53.13%	59.01%	55.91%
Bernhard	MorphoNet	65.08%	47.82%	55.13%
Monson et al.	ParaMor-Morfessor Mimic	54.80%	60.17%	57.36%
Lavallée & Langlais	RALI-COF	68.32%	46.45%	55.30%
Can & Manandhar	-	58.52%	44.82%	50.76%
-	Morfessor CatMAP	84.75%	35.97%	50.50%
Spiegler et al	PROMODES	36.20%	64.81%	46.46%
Lavallée & Langlais	RALI-ANA	64.61%	33.48%	44.10%
Spiegler et al.	PROMODES 2	32.24%	61.10%	42.21%
Spiegler et al.	PROMODES committee	32.24%	61.10%	42.21%
Tchoukalov et al.	MetaMorph	68.41%	27.55%	39.29%
Golénia et al.	UNGRADE	28.29%	51.74%	36.58%
-	letters	3.82%	99.88%	7.35%

Author	Method	Precision	Recall	F-measure
Virpioja & Kohonen	Allomorfessor	68.98%	56.82%	62.31%
-	Morfessor Baseline	74.93%	49.81%	59.84%
Monson et al.	ParaMor-Morfessor Union	55.68%	62.33%	58.82%
Lignos et al.	-	83.49%	45.00%	58.48%
Monson et al.	ParaMor Mimic	53.13%	59.01%	55.91%
Bernhard	MorphoNet	65.08%	47.82%	55.13%
Monson et al.	ParaMor-Morfessor Mimic	54.80%	60.17%	57.36%
Lavallée & Langlais	RALI-COF	68.32%	46.45%	55.30%
Can & Manandhar	-	58.52%	44.82%	50.76%
-	Morfessor CatMAP	84.75%	35.97%	50.50%
Spiegler et al	PROMODES	36.20%	64.81%	46.46%
Lavallée & Langlais	RALI-ANA	64.61%	33.48%	44.10%
Spiegler et al.	PROMODES 2	32.24%	61.10%	42.21%
Spiegler et al.	PROMODES committee	32.24%	61.10%	42.21%
Tchoukalov et al.	MetaMorph	68.41%	27.55%	39.29%
Golénia et al.	UNGRADE	28.29%	51.74%	36.58%
-	letters	3.82%	99.88%	7.35%
Monson et al. 2008	ParaMor + Morfessor	69.59%	65.57%	67.52%
Monson et al. 2008	ParaMor	63.32%	51.96%	57.08%
Bernhard 2007	2	67.42%	65.11%	66.24%

German (Competition 1).

Author	Method	Precision	Recall	F-measure
Monson et al.	ParaMor-Morfessor Union	52.53%	60.27%	56.14%
Monson et al.	ParaMor-Morfessor Mimic	51.07%	57.79%	54.22%
-	Morfessor CatMAP	71.08%	38.92%	50.30%
Monson et al.	ParaMor Mimic	50.81%	47.68%	49.20%
Can & Manandhar	2	57.67%	42.67%	49.05%
Lavallée & Langlais	RALI-COF	67.53%	34.38%	45.57%
Spiegler et al.	PROMODES 2	36.11%	50.52%	42.12%
Virpioja & Kohonen	Allomorffessor	77.78%	28.83%	42.07%
Bernhard	MorphoNet	67.41%	30.19%	41.71%
Spiegler et al.	PROMODES	49.88%	33.95%	40.40%
Spiegler et al.	PROMODES committee	48.48%	34.61%	40.39%
-	Morfessor Baseline	81.70%	22.98%	35.87%
Lignos et al.	-	78.90%	21.35%	33.61%
Golénia et al.	UNGRADE	39.02%	29.25%	33.44%
Tchoukalov et al.	MetaMorph	39.59%	19.81%	26.40%
Can & Manandhar	1	73.16%	15.27%	25.27%
Lavallée & Langlais	RALI-ANA	61.39%	15.34%	24.55%
-	letters	2.79%	99.92%	5.43%
Monson et al. 2008	ParaMor + Morffessor	64.06%	61.52%	62.76%
Monson et al. 2008	ParaMor	70.73%	38.82%	50.13%
Bernhard 2007	2	54.02%	60.77%	57.20%

Turkish (Competition 1).

Author	Method	Precision	Recall	F-measure
Monson et al.	ParaMor-Morfessor Mimic	48.07%	60.39%	53.53%
Monson et al.	ParaMor-Morfessor Union	47.25%	60.01%	52.88%
Monson et al.	ParaMorMimic	49.54%	54.77%	52.02%
Lavallée & Langlais	RALI-COF	48.43%	44.54%	46.40%
-	Morfessor CatMAP	79.38%	31.88%	45.49%
Spiegler et al.	PROMODES 2	35.36%	58.70%	44.14%
Spiegler et al.	PROMODES	32.22%	66.42%	43.39%
Bernhard	MorphoNet	61.75%	30.90%	41.19%
Can & Manandhar	2	41.39%	38.13%	39.70%
Spiegler et al.	PROMODES committee	55.30%	28.35%	37.48%
Golénia et al.	UNGRADE	46.67%	30.16%	36.64%
Tchoukalov et al.	MetaMorph	39.14%	29.45%	33.61%
Virpioja & Kohonen	Allomorfessor	85.89%	19.53%	31.82%
-	Morfessor Baseline	89.68%	17.78%	29.67%
Lavallée & Langlais	RALI-ANA	69.52%	12.85%	21.69%
-	letters	8.66%	99.13%	15.93%
Can & Manandhar	1	73.03%	8.89%	15.86%
Monson et al. 2008	ParaMor + Morfessor	66.78%	57.97%	62.07%
Monson et al. 2008	ParaMor	57.35%	45.75%	50.90%
Bordag 2007	5a	81.06%	23.51%	36.45%

Table 10: The submitted unsupervised morpheme analyses compared to the gold standard **vowelized Arabic** (Competition 1).

Author	Method	Precision	Recall	F-measure
-	letters	50.56%	84.08%	63.15%
Spiegler et al.	PROMODES 2	63.00%	59.07%	60.97%
Spiegler et al.	PROMODES committee	68.32%	47.97%	56.36%
Golénia et al.	UNGRADE	72.15%	43.61%	54.36%
Spiegler et al.	PROMODES	74.85%	35.00%	47.70%
-	Morfessor Baseline	86.87%	4.90%	9.28%
Monson et al.	ParaMor-Morfessor Union	91.61%	4.41%	8.42%
Virpioja & Kohonen	Allomorfessor	88.28%	4.37%	8.33%
Monson et al.	ParaMor-Morfessor Mimic	93.62%	3.23%	6.24%
Bernhard	MorphoNet	92.52%	2.91%	5.65%
Tchoukalov et al.	MetaMorph	88.78%	2.89%	5.59%
Lavallée & Langlais	RALI-ANA	91.30%	2.83%	5.49%
Monson et al.	ParaMor Mimic	91.36%	1.85%	3.63%
Lavallée & Langlais	RALI-COF	95.09%	1.50%	2.95%

Table 9: The submitted unsupervised morpheme analyses compared to the gold standard in **non-vowelized Arabic** (Competition 1).

Author	Method	Precision	Recall	F-measure
-	letters	70.48%	53.51%	60.83%
Spiegler et al.	PROMODES 2	76.96%	37.02%	50.00%
Spiegler et al.	PROMODES committee	77.06%	36.96%	49.96%
Spiegler et al.	PROMODES	81.10%	20.57%	32.82%
Golénia et al.	UNGRADE	83.48%	15.95%	26.78%
Virpioja & Kohonen	Allomorfessor	91.62%	6.59%	12.30%
-	Morfessor Baseline	91.77%	6.44%	12.03%
Bernhard	MorphoNet	90.49%	4.95%	9.39%
Monson et al.	ParaMor-Morfessor Union	93.72%	4.81%	9.14%
Monson et al.	ParaMor-Morfessor Mimic	93.76%	4.55%	8.67%
Lavallée & Langlais	RALI-ANA	92.40%	4.40%	8.41%
Tchoukalov et al.	MetaMorph	95.05%	2.72%	5.29%
Monson et al.	ParaMor Mimic	91.29%	2.56%	4.97%
Lavallée & Langlais	RALI-COF	94.56%	2.13%	4.18%



Conclusions

- The best method in 2008 (by Monson) still unbeaten
- Performances varies between the tasks
- Features used in the gold standard affect the level of F-scores in each language
- Best algorithm in FIN, GER and TUR: Monson **ParaMor + Morfessor**, combined analysis
- Best in ENG: **Allomorfessor** by Virpioja & Kohonen
- Best in ARA: Spiegler **Promodes 2**



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