Allomorfessor: Towards Unsupervised Morpheme Analysis

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Outline

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Allomorphy

Definition: One morpheme-level unit may have two or more morph-level surface realizations which only occur in a complementary distribution

Examples

- `/prettI/ pretty pretti-er`
- `/kenkä/ (shoe) kenkä kengä-n`

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Finding allomorphs

Allomorphs often very similar to a hypothetical regular form:

- `prettier` vs `*prettyer`
- `kengän` vs `*kenkän`

Use string similarity to find potential allomorphs.

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Finding allomorphs

General metrics of string similarity inappropriate for allomorphy identification.

- `beat` vs `peat` (Levenshtein distance = 1)

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Observation: Most allomorphic variation close to boundary between stem and affix.

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Observation: Most allomorphic variation close to boundary between stem and affix.
Solution: Use *string mutations* to encode prior information into model.

Mutations

Simplest thing that could possibly work:

- `pretti` = `pretty -y +i`

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Problem: `kenkä` – `kengän` and `tanko` – `tangon`

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Solution:

- Allow only deletions and substitutions
- Begin from end of virtual prefix. Find first matching letter, apply operation to that one ⇒ `k|g`
- Efficiently computed via Levenshtein algorithm

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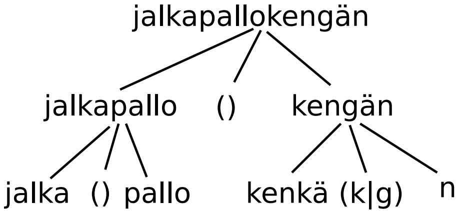
Model description

Morfessor-Baseline inspired segmentation model with added mutations.



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Model description

MAP Formulation:

$$\begin{aligned}\mathcal{M}_{\text{MAP}} &= \arg\max_{\mathcal{M}} P(\mathcal{M}|\text{corpus}) \\ &\propto \arg\max_{\mathcal{M}} P(\text{corpus}|\mathcal{M})P(\mathcal{M}) \\ &= \arg\max_{\mathcal{G}_M,\mathcal{L}_M} P(\mathcal{L}_W|\mathcal{G}_M,\mathcal{L}_M)P(\mathcal{G}_M)P(\mathcal{L}_M).\end{aligned}$$

Segmentation principle

A morph is either generated by:

- String of letters $P(\mathrm{length}(\mu_i)) \prod_{j=1}^{\mathrm{length}(\mu_i)} P(\hat{c}_{ij})$
- Two virtual submorphs $P(\mu_j)P(\delta_k)P(\mu_k)$

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Example:

- String of letters $P(\text{prettier}) = P(\text{length}(\text{prettier}))P(\text{p})P(\text{r})P(\text{e})P(\text{t})P(\text{t})P(\text{i})P(\text{e})P(\text{r})$
- Two virtual submorphs $P(\text{prettier}) = P(\text{pretty})P(\text{y}|\text{i})P(\text{er})$

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Model Learning

Go through words in random order. For each word w, evaluate model probability for different analyses and choose the most probable:

1. No-split, w generated from letters
2. Split word at position i:
   - $w_{..i}$ as virtual prefix, $w_{(i+1)..}$ as virtual suffix, mutation empty
   - If virtual suffix $w_{(i+1)..}$ exists in lexicon, consider mutated forms. Find (at most K) forms that share a prefix with $w_{..i}$, calculate the required mutation.

If the best analysis involved a split, then recursively analyze both parts.

Continue with next word. Repeat for all words, start over, until convergence.

Results

Language	*Precision*	*Recall*	*F-Measure*	*Winner F*
English	83.39%	13.43%	23.13%	56.26%
German	87.92%	7.44%	13.71%	54.06%
Turkish	93.25%	6.15%	11.53%	51.99%
Finnish	92.55%	6.89%	12.82%	48.47%

Model undersegments, but found segments are accurate.

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Example analyses

Mutation	Freq.	Example
-e	2033	abjure (-e) ed
-s	537	actress (-s) s'
-y	386	inequity (-y) able
-n	243	suspicion (-n) ns
-d-e	183	contructed (-d-e) ive

Mutation	Freq.	Example
(-n)	27510	antiikin (-n) lle
(-n-e)	15830	edustajien (-n-e) esi
(-a)	6241	haljeta (-a) essa
(-i)	4203	kliimaksi (-i) in
(-a-t)	2792	alokkaita (-a-t) lle

Conclusions

- Allomorphy is an important phenomenon in morphology
- A statistical model can learn allomorphic variation to a degree
- Further work needed to get results to state-of-art level

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