The Crúbadán Project

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Project Goals

- Creation of web-crawled corpora for many minority and “under-resourced” languages
- Development of open source language-processing tools for these languages, in collaboration with native speakers
  - Clean word lists
  - Simple morphology engines for spell checking
  - Part-of-speech tagging
  - In some cases, parsers, semantic networks, and other advanced tools

Under-Resourced NLP

- Often no public funding available and no commercial interest in this work
- Few native speakers with NLP training
- Data are too scarce for “representativeness”
- To overcome these obstacles, we use:
  - An open source development model
  - Volunteer labor by language enthusiasts
  - Free, web-crawled corpora
  - Language-independent tools (like our crawler) deployed for a large number of languages
  - Unsupervised machine learning algorithms

Project Status

- Corpora for 416 languages
- For 355 of these languages, our crawler has been unable to find additional texts: “languages with a limited web presence”
- For the remaining languages (English, French, Chinese, etc.), we have only crawled enough text to generate reliable language recognition statistics
- 278 791 documents, 320M words, 2.5GB after conversion to plain text

Some History

- Circa 2000: Original software recursively downloaded entire web sites and then distinguished English and the six Celtic languages offline
- 2003-2004: turned this into a true web crawler and trained language models for 144 under-resourced languages (Crúbadán 1.0)
- 2007: expanded coverage to include many more non-Latin-script languages, bringing the total up to 416 languages (Crúbadán 2.0)

Fundamental Algorithm: Lexicon Generator

- Algorithm takes a corpus as input and tries to output a clean word list (the “lexicon”)
- This is done with a cascade of “noise filters”:
  - Tokens with unusual characters
  - Tokens with no vowels (if appropriate)
  - Tokens with improbable three-grams
  - Tokens with late titlecase or uppercase
  - Tokens which are words in a “polluting language”
  - Tokens which may have had diacritics stripped
  - Tokens not collocated with any high-freq. word
  - Additional language-specific filters when known

Design of the Web Crawler, I

- Independent processes target one language at a time, enabling more efficient coverage of languages with a limited web presence
- Each language has one or more “stopwords” for generating queries (either from a native speaker or extracted from frequency list)
- Queries are generated by OR'ing together random words from the “lexicon” and then AND'ing a stopword; these are sent to the Google API

Design of the Web Crawler, II

- Download URLs returned by Google, convert to text using standard open source tools
- Three-gram language recognizer is applied at the document level (character 3-grams), with language-dependent threshold
- Naive Bayes classifier in problematic cases
- If document is in the target language, extract all URLs and add them to the “pending” list
- When crawling finishes, strip duplicates, flag “unproductive” domains, generate new lexicon, update 3-gram statistics, etc.

Training New Languages

- All that is needed is a sufficient amount of text to generate reliable 3-gram statistics
- Thusfar most training data have come from three sites: the Wikipedia, the Jehovah's Witnesses web site, and the UN UDHR
- More recently, also using offline training texts for languages currently lacking any web presence
- With training texts in place and tokenized, the lexicon generator is applied and 3-gram statistics generated from this “clean” word list

Native Speaker Input

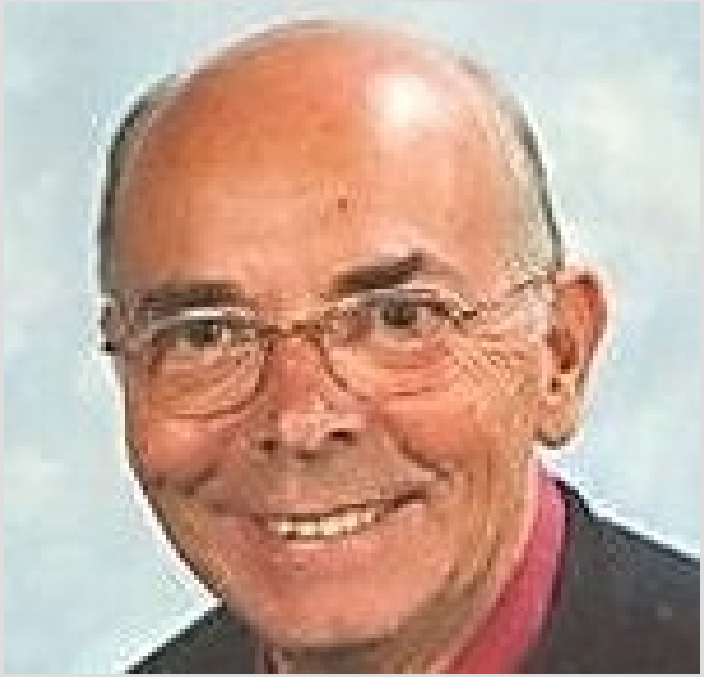
- Community-based effort is essential
- Web crawling
  - Help decipher legacy encodings (three examples in paper: Mongolian, Hawaiian, and Irish “be/al” vs. “béal”). XNLRDF (Streiter & Stuflesser)
  - Help with tokenization
  - Language-specific lexicon filters
  - Verify language recognition, separate dialects
- Applications
  - Editing and tagging word lists
  - Morphological analysis

New Open Source Spellcheckers

- Azerbaijani
- Chichewa
- Cornish
- Hiligaynon
- Irish
- Kashubian
- Kinyarwanda
- Kurdish
- Malagasy
- Manx Gaelic
- Mongolian
- Scottish Gaelic
- Setswana
- Tagalog
- Tetum
- West Frisian
- Coming Soon: Guarani, Hawaiian, Somali, ...

Case Study: West Frisian

- Germanic language with about 500 000 speakers, most in the Netherlands
- Done over three weeks in Feb. 2007 in collaboration with Eeltje de Vries, a retiree with a background in theoretical physics



Morphological Description

- Root words with one or two prefixes and one or two suffixes; not a full transducer
- This simplified description is easily encoded by novices and well-supported in open source tools (OpenOffice.org, Mozilla FF/TB)

```
# Affix file syntax:
# [PS]FX name strip add match

# moai->moaie, kreas->kreaze
SFX S 0 e [^esh]
SFX S ch ge ch
SFX S s ze s

# moai->moaier, kreas->kreazer
SFX T 0 er [^es]
SFX T 0 r e
SFX T s zer s

# moai->moaist, kreas->kreast
SFX U 0 st [^es]
SFX U 0 t s

...
```

Extract root words from corpus

```
wurdearje/V (5/5): wurdearje(18), wurdearrest(1), wurdearret(1),
wurdearre(26), wurdearren(3), wurdearjend(1)

reagearje/V (5/5): reagearje(15), reagearrest(1), reagearret(13),
reagearre(17), reagearren(3), reagearjend(1)

ynspirearje/V (4/5): ynspirearje(11), ynspirearrest(0), ynspirearret(2),
ynspirearre(23), ynspirearren(1), ynspirearjend(12)

studearje/V (4/5): studearje(27), studearrest(0), studearret(17),
studearre(34), studearren(4), studearjend(1)

konsumearje/V (4/5): konsumearje(1), konsumearrest(0), konsumearret(1),
konsumearre(2), konsumearren(1), konsumearjend(1)

funksjonearje/V (4/5): funksjonearje(7), funksjonearrest(0),
funksjonearret(9), funksjonearre(5), funksjonearren(1), funksjonearjend(1)

tramtearje/V (4/5): tramtearje(2), tramtearrest(0), tramtearret(1),
tramtearre(1), tramtearren(1), tramtearjend(1)

presintearje/V (3/5): presintearje(11), presintearrest(0),
presintearret(5), presintearre(34), presintearren(3), presintearjend(0)

komponearje/V (3/5): komponearje(1), komponearrest(0), komponearret(1),
komponearre(2), komponearren(1), komponearjend(0)

.........
```

Results

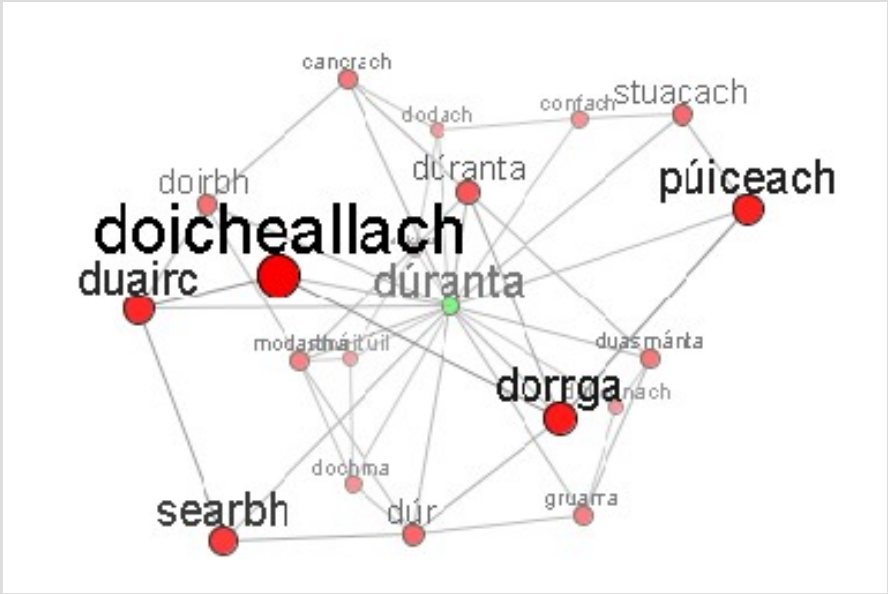
- Hand-checked lexicon with 22011 root words and 38677 derived forms
- Morphology ensures obscure inflected forms are included, unlike a pure corpus approach
- Spell checker recall is 91% on testing corpus (95% is an approximate expected upper bound on recall for uncleaned web corpora)
- It is also possible to train a part-of-speech tagger using Eric Brill's (unsupervised) transformation-based learning algorithm, but we have not evaluated this since we know of no existing tagged corpus

Semantic Networks

- Combine simple Xish-English dictionary, monolingual Crúbadán corpus for Xish, and Princeton WordNet for English
- Suffices to map Xish words over to one or more WordNet synsets
- Irish e.g.: *feileastram* defined as “flag, iris” (ambiguous English words), but collocated in the corpus with *bláth, féar* which mean (again using the dictionary) “bloom”, “grass”. These English words are closest to the correct WordNet senses of “flag” and “iris”.

3-Dimensional Graph Browser

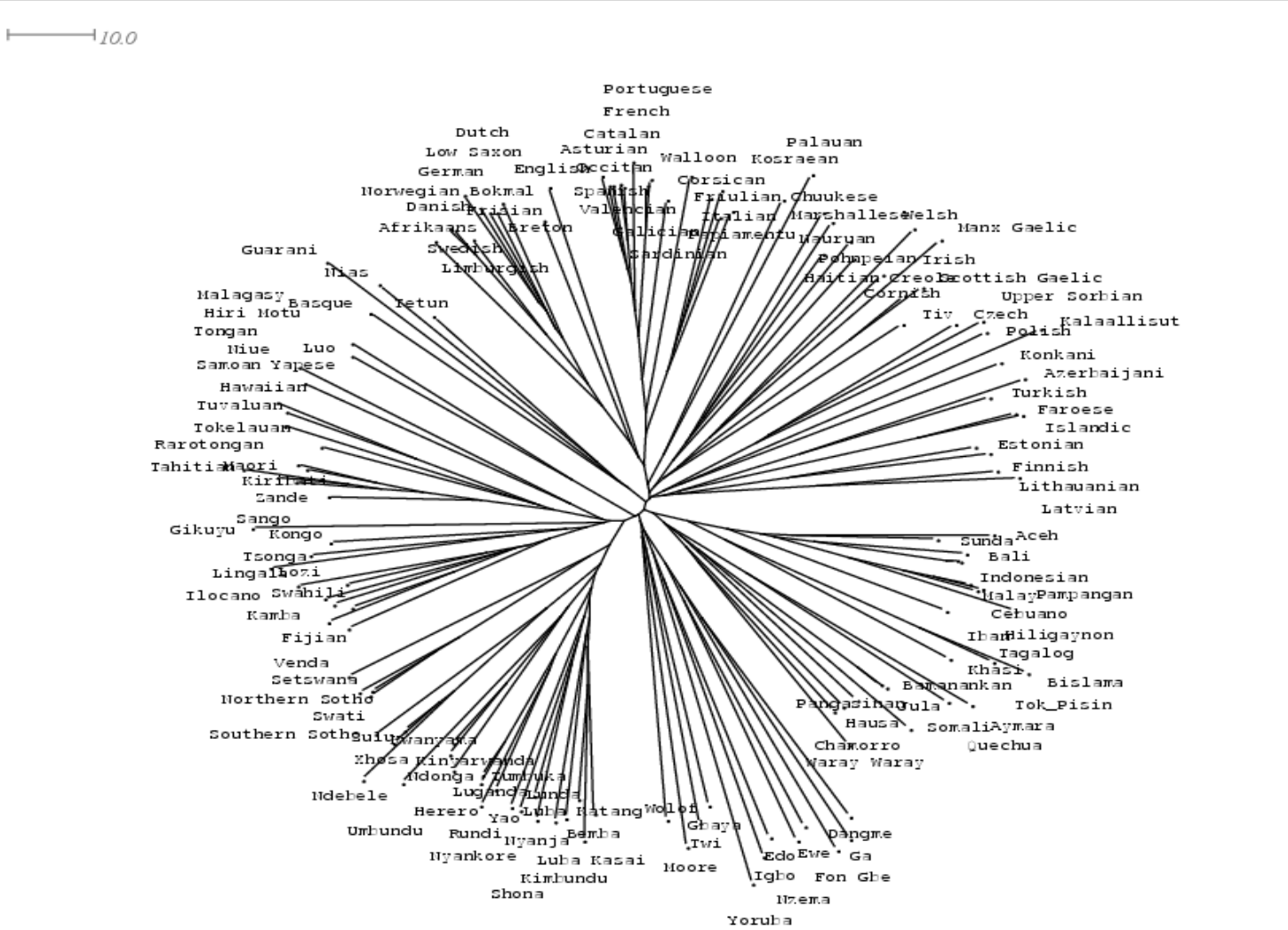
- Irish semantic network is available via an interactive three-dimensional graph browser written in Java
- Click nodes to navigate the network, click and drag to rotate in 3D



Phylogenic Tree Reconstruction

- Work in progress with Michael Cysouw of MPI Leipzig
- Use the huge grid of 3-gram cosines for all language pairs to reconstruct an “orthographic” family tree for languages
- The result matches up surprisingly well with the actual tree of language families, as encoded, e.g., in the Ethnologue
- Can improve this naïve approach by a transliterating non-Latin character sets, using coarse phonetics, etc.

The Orthographic Tree



Availability of Corpora

- We have provided corpora to more than 50 research groups and individuals working with under-resourced languages
- Only requirement is that results of research using the Crúbadán corpora be made freely available under an open source license
- Available as plain text without any special cleaning of boilerplate text or pollution
- Can also provide lists of URLs or raw HTML/PDF (if you have bandwidth and a preferred toolchain for converting to text)

Future Plans

- Apply high-quality cleaning algorithms to all corpora
- Continue to train new language models; goal is 1000 languages with the help of offline training texts
- Open source spell checkers for 100 languages
- Part-of-speech tagging for 25 languages

Call to Action

- Embrace an open-source approach when developing language technologies, especially for under-resourced languages or when public funding is involved (see forthcoming paper with O. Streiter and M. Stuflesser)
- Spend two or three hours a week working in support of an under-resourced language – there are thousands to choose from and many will not be around much longer

Thanks

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