Towards explainable AI for Irish grammatical error correction
Grammatical error correction

- Task takes a sentence as input, and outputs the sentence with errors corrected.
- Easier problem: grammatical error detection.
- Harder problem: Grammatical error detection/correction plus explanations.
- Research is mostly on English; small datasets for maybe 20 languages total.
- Definition of what constitutes an error is fuzzy; defined by the datasets!
- Exceptionally difficult task: SOTA F-scores in the 60’s for English (low recall)
Celtic initial mutations

- Celtic languages have initial mutations usually triggered by context
- *bád seoil* “sailboat”, *mo bhád seoil* “my sailboat”, *ár mbád seoil* “our sailboat”
- Gender: *fear* “man”, *an fear bocht* “the poor man”, but:
- *bean* “woman”, *an bhean bhocht* “the poor woman”
- Dative case: *ar an mbád seoil* “on the sailboat” (or, *ar an bhád seoil*)
- Genitive plural: *leithreas na bhfear*
  - toilet DET.GEN.PL men.GEN.PL
  - “the men’s toilet”
Official Standard(s)

- First version published in 1958, revised in 2012 and then 2017
- Among other things, rules for when the various mutations should be used
- But...
  - Not fully aligned with existing grammars and dictionaries (including CB, FGB, NEID)
  - Standard form is “artificial” — doesn’t agree with the way native speakers use the language
  - Many divergences according to dialect
  - Even accepting all of this, rules leave quite a bit up to interpretation
  - So we see variance even among those committed to the standard
  - Upshot for us: no completely reliable training data exists!
One problematic example (of dozens)

- “saoirse cainte” or “saoirse chainte”?
- 177M word corpus: “saoirse cainte” 687 times and “saoirse chainte” 28 times
- “saoirse creidimh” or “saoirse chreidimh”?
- Same corpus: 85 times vs. 26 times
freedom

1 NOUN power, latitude

saoirse fem. - saoirse

she has the freedom to make her own decisions tá an tsaoirí
tá sí saor chun a cinní féin a dhéanamh

to live in freedom from fear maireachtáil saor ó eagla
freedom of movement saoirse ghluaiseachta
freedom of speech saoirse labhartha, saoirse chainte
freedom of thought saoirse smaointeoireachta
political freedom saoirse polaitíochta
religious freedom saoirse chreidimh, saoirse religiuín

saoirse

2. Liberty, independence. ~ na tíre, the freedom of the
country. ~ cainte, freedom of speech. ~ coinsiasa, liberty of conscience. ~ de húiné, human freedom; personal liberty.
3. Immunity, exemption. ~ ó chánacha, exemption from taxes.

5. Honorary privilege. ~ na cathrach, the freedom of the city.
6. Cheapness, inexpensiveness.

Phrases and Examples in other entries

curtailment » it's a curtailment of freedom of speech is ciorrú ar shaoirse cainte é
enjoyment » the government must facilitate the enjoyment of the freedom of
speech caithfidh an rí tartas saoirse cainte an phobail a éascú
freedom » freedom of speech saoirse labhartha, saoirse chainte
limit » they can't limit freedom of speech ní féidir leo srian a chur le saoirse
profess » They profess to support freedom of speech maionn siad go bhfuil siad
i bhfáth le saoirse cainte

- This initial attempt was based on explicit rules
- Perform part-of-speech tagging, and then apply pattern-matching rules
- Exceptions, and exceptions to the exceptions, etc. (2814 rules in all)
  - Positive: possible to provide explanations/diagnoses when errors are flagged
  - Negative: usual brittleness of rule-based systems
  - Negative: tedious to implement all the rules; exceptionally hard to maintain them
  - Negative: some rules depend on semantics or syntax and can’t be encoded in this formalism
Unsupervised approach

- If you sacrifice the explanations, can predict mutations in an unsupervised way.
- Formulate this as a tagging problem with five tags: N, S, U, T, H.
- Can (almost) remove mutations algorithmically => unlimited training data.
- I knew this in 2004, but it was hard to get right using n-gram language models.
- Some rules depend on subtle character-level info (slender endings, etc).
- Generalized parallel backoff (Bilmes and Kirchhoff).
Neural system: 17–18 October 2019

- Neural model: eliminates the hard parts of the statistical approach
- LSTM layer(s), BiLSTM at character level
- No need to hand-select features; no complicated backoff schemes
- Achieves much higher accuracy than previous approaches
- Character-based component learns gender other relevant features ("snideog")
- Word-based component learns sometimes subtle contextual clues ("Ó Baoill")
Digression: entropy of mutations

- Network has a five-fold softmax at the top, trained to minimize cross-entropy.
- Best model achieves entropy very close to zero; under 0.07 bits per word.
- Informally, “Irish initial mutations carry virtually no information”, empirically.
- Even stronger; more than half of the loss caused by errors in the test set!
- Remainder are things like 3rd person possessives (well-known).
- Some with zero impact: direct vs. indirect relatives.
Critique

- Learns mutations as used by the language community, “errors” included
- Makes some inexplicable mistakes; difficult to debug
- Easy things are easy for it; less effective on the cases humans find difficult
- No explanations given
How do we get the explanations back?

- Want to keep it as a tagging problem but with an enhanced set of tags
- Augment each tag with a section of the official standard that “explains” it
- \( Tá \ an \ bhean/S+10.2.1 \ ag \ canadh \)
- \( Tá \ an \ doineann/N+10.2.1.e1 \ ag \ maolú \)
- Just need to produce millions of training examples, somehow :/

### 10.2.1 Ndiaidh an Ailt

Cuirtear séimhiú ar an ainmfhocal i ndiaidh an ailt (mura \( d, t \) nó \( s \) an túschonsan)–

(a) san ainmneach uatha baininscneach, e.g., \( an \ chathair; an \ ghloine; an \ fhuascailt. \)

- \( Tá \ an \ bhean \ ag \ canadh. \)
- Ar dhún sé \( an \ fhuinneog? \)
Universal Dependencies

Bhí an lá an-te agus bhí gach duine spalptha leis an tart
Be-PAST the day very-hot and be-PAST every person parched with the thirst
‘The day was very hot and everyone was parched with the thirst’

Celtic UD treebanks

- Scottish Gaelic: [Colin Batchelor](#) (2019)
- Manx Gaelic: [Scannell](#) (2020)
- Welsh: [Heinecke and Tyers](#) (2019)
- Breton: [Tyers and Ravishankar](#) (2018)
- Cornish: ???

Considerable effort has gone into in harmonizing annotation schemes
 Allows cross-linguistic comparison and transfer learning
Bhí sí naoi mbliana agus leathchéad.
Feature Prediction

- I developed a suite of QA tools for checking the Irish treebank(s) in 2021
- [https://github.com/kscanne/grammatatch](https://github.com/kscanne/grammatatch)
- Implements “constraints” on feature values based on dependency relations
- For our purposes, enough that the “Form” feature captures mutations
- Refactored this code to parallel the rules in the standard to the extent possible
if head('lemma') in gadate.feminineGroups:
    return [Constraint('Len', '10.2.7.j: Do not lenite a genitive noun after a feminine noun for groups or organizations')]

    if self['lemma'] in ['dli', 'si']:
        return [Constraint('Len', '10.2.7.k: Do not lenite "dli" or "si" after a feminine noun')]

    if self['lemma'] in ['bláin', 'coicis', 'mí', 'seachtain']:
        return [Constraint('Len', '10.2.7.l: Do not lenite various units of time after a feminine noun')]

    if self.isQualifiedNoun():
        if head('lemma') in ['beirt', 'dis']:
            return [Constraint('Len', '10.2.7.m.e1: Lenite nouns after "beirt" or "dis" even if the genitive noun is modified by an adjective or another noun')]

            return [Constraint('Len', '10.2.7.m: Do not lenite after a feminine noun if the genitive noun is modified by an adjective or another noun')]

(j) Ní shéimhitear an dara hainmhfocal i ndiaidh na bhfocal aicme, comhairle, corporáid, cuideachta, earnáil, feidhimeanachta, foireann, gnìomhaireachta, instiistiúid, osfg, rannóg, roinn, scéim, seirbhís, e.g., aicme ceannais; comhairle contar; corporáid bainistiúchátha; earnáil gnó; foireann bainistiúchátha; instiistiúid breisideachta; osfg preasa; rannóg pearsanta; roinn cosanta.

(k) Ní foláir dóibh an scéim marcála a choigeartú.
    Cuireann an gnólaict seirbhís comhairloireachta ar fáil.

(l) Ní shéimhitear na hainmhfocal d lil ná slí i ndiaidh ainmhfocal baininseachta, e.g., feidhm dí bá sí.
    Cuirfidiú an rialtais cóip den ionstraim dí ar fáil.
    Deirtear gur comharthar an mhí-sídh an long sí a fheiceáil.

(m) Ní shéimhitear an dara hainmhfocal más ceann de na haonaidh toimhse bhreacach bliain, coicis, mí nó seachtain an dara hainmhfocal, e.g., saoire míosa; tréimhse bliana; marc bliana.
    Cuireadh tús leis an bhfíeile seachtaine le hóidic i dteach ar Mhóra.
    Bhí scith coiscís de dhitich ùrthi tar éis na hoibre.

(m) Ní raibh deoirt bainne úir fágtha sa teach.
    Cuireadh an obair tionscadail aistriúcháin i gcrích inní.

Eíseacht: nuair is é beirt nó dís an chéad ainmhfocal, e.g., beirt bhan mhóinniúla nó nuair is é beirt an dara hainmhfocal, e.g., paistí theirt bhain.
Corpus-level survey of errors

<table>
<thead>
<tr>
<th>Error</th>
<th>Sample error</th>
<th>Total</th>
<th>Errors</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>10.2.5.a.e1</td>
<td>um bhainistíocht</td>
<td>2</td>
<td>2</td>
<td>100.00%</td>
</tr>
<tr>
<td>10.3.1.d.ii</td>
<td>sé chúrsa páirtaimseartha</td>
<td>1</td>
<td>1</td>
<td>100.00%</td>
</tr>
<tr>
<td>10.3.1.d.i</td>
<td>dhá chúrsa páirtaimseartha</td>
<td>6</td>
<td>3</td>
<td>50.00%</td>
</tr>
<tr>
<td>10.2.6: Sc in aghaidh Binse na Stáitseirbhís</td>
<td>40</td>
<td>16</td>
<td>40.00%</td>
<td></td>
</tr>
<tr>
<td>10.2.8.a: D faoi chórais theilifise</td>
<td>23</td>
<td>5</td>
<td>21.74%</td>
<td></td>
</tr>
<tr>
<td>10.11.2.a: S an tríú áit</td>
<td>21</td>
<td>4</td>
<td>19.05%</td>
<td></td>
</tr>
<tr>
<td>10.2.7.j: Dc earnáil chruach</td>
<td>69</td>
<td>10</td>
<td>14.49%</td>
<td></td>
</tr>
<tr>
<td>10.4.1.i.e1: tánghas</td>
<td>8</td>
<td>1</td>
<td>12.50%</td>
<td></td>
</tr>
<tr>
<td>10.2.4.c.e1 trí throigh</td>
<td>34</td>
<td>4</td>
<td>11.76%</td>
<td></td>
</tr>
<tr>
<td>10.2.5.c.e1 gan chomhaoin luachmhar</td>
<td>9</td>
<td>1</td>
<td>11.11%</td>
<td></td>
</tr>
<tr>
<td>10.2.9: Do le linn an tséasúir mhárseála</td>
<td>243</td>
<td>15</td>
<td>6.17%</td>
<td></td>
</tr>
<tr>
<td>10.2.1.c: Al don bhfile</td>
<td>645</td>
<td>39</td>
<td>6.05%</td>
<td></td>
</tr>
<tr>
<td>10.2.8.b: D ar chumais fhiontraíochta</td>
<td>17</td>
<td>1</td>
<td>5.88%</td>
<td></td>
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<tr>
<td>10.2.5.a: Sí faoi clár</td>
<td>146</td>
<td>7</td>
<td>4.79%</td>
<td></td>
</tr>
<tr>
<td>10.2.3.b: Al chuile duine</td>
<td>24</td>
<td>1</td>
<td>4.17%</td>
<td></td>
</tr>
<tr>
<td>10.6.3: Shc ocht bliana</td>
<td>49</td>
<td>2</td>
<td>4.08%</td>
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<td>10.11.3: Sh le iscaire</td>
<td>218</td>
<td>8</td>
<td>3.67%</td>
<td></td>
</tr>
<tr>
<td>10.4.2.b: Fí inar dhúirt sé</td>
<td>141</td>
<td>5</td>
<td>3.55%</td>
<td></td>
</tr>
</tbody>
</table>
Synthetic training data

- Produce dependency parses for sentences in a large corpus
- Ignore tokens with incorrect features according to QA scripts
- (Mix of incorrect parses and corpus examples not compliant with standard)
- Each remaining token is attached to one or more constraints
- Intentionally violate those constraints by changing the mutation and add tag:
  - Correct sentence: Tá an bhean ag canadh
  - Constraint on “bhean” requires the S tag with reference 10.2.1
  - Can violate this two ways: Tá an bean/S+10.2.1 ag canadh
    Tá an mbean/S+10.2.1 ag canadh
- Training works much like the previous paper (test set in progress)
Benefits and future directions

- Neatly handles the issue of non-standard texts in training
- Can oversample rare mutation contexts that the previous model failed on
- No reason to limit to mutation features (errors in agreement verb tense, etc.)
- Approach should apply neatly to the 4 other Celtic languages with treebanks
Thank you! / Go raibh maith agaibh!

- https://cadhan.com/
- https://github.com/kscanne/