Subword Modeling

11-324/11-824

For up-to-date information, see the course webpage at
`https://dmort27.github.io/subwordmodeling/`.

1 Instructors

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2 Schedule

Do not panic: students are expected to do **one** reading for each class period (not the whole set of readings).

Table 1:

LEC	TOPIC	READINGS	DUE
	Module 1: Morphemes		
1	Introduction; introduction to Project 1	Haspelmath and Sims (2010) Ch 1–2 Park et al. (2021); Church (2020),	
2	Signs, minimal signs, and compositionality		
3	Productivity	Haspelmath and Sims (2010); Park et al. (2021), Ch 6	
4	Inflection, derivation, and compounding	Haspelmath and Sims (2010), Ch. 5; Matthews (1974), Ch. 5; Chaudhary et al. (2020); Hofmann et al. (2021)	
5	Morphotactics, affix ordering, the mirror principle, and the relevance principle	Aksënova et al. (2016)	

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Table 1: (Continued)

6	Computational approaches to morphological segmentation/tokenization (unsupervised [BPE, sentencepiece, Morfessor, etc.], supervized)	Sennrich et al. (2016); Mielke et al. (2021); Creutz and Lagus (2005); Virpioja et al. (2013); Khandagale et al. (2022); Bostrom and Durrett (2020); Hofmann et al. (2022)	
7	Allomorphy	Matthews (1974), Ch 6; Haspelmath and Sims (2010), Ch. 10; Yıldız et al. (2019)	
8	Non-concatenative processes	Amrhein and Sennrich (2021); Klein and Tsarfaty (2020); Fullwood and O'Donnell (2013); Haley and Wilson (2021)	
	Module 2: Lexemes		
9	Lexemes and paradigms; introduction to Project 2	Matthews (1974), Ch. 2; Haspelmath and Sims (2010), Ch. 8	
10	Grammatical properties	Matthews (1974), Ch. 9; Sylak-Glassman (2016)	Project 1
11	Word-and-Paradigm morphology	Matthews (1974), Ch 10	
12	Rules of realization and rules of referral: a computational system for WP morphology		
13	Neural approaches to reinflection	Cotterell et al. (2016); Pimentel et al. (2021)	
14	Neural approaches to paradigm completion	Jin et al. (2020); Wiemerslage et al. (2022)	
	Module 3: Graphemes		
15	Descriptive phonetics	International Phonetic Association (1999, 1–37)	
16	IPA versus orthographies. Introduction to Project 3		
17	Typology—alphabets, abjads, abugidas, syllabaries, logographic scripts, and others	Hockett et al. (1997)	Project 2
18	G2P and P2G	Mortensen et al. (2018); Li et al. (2022)	
19	Unicode—logical and visual representations	(Haralambous and Dürst, 2019)	

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Table 1: (Continued)

20	Input methods (ML and HCI perspectives)	van Esch et al. (2019)	
	Module 4: Sounds		
21	Articulatory features; introduction to Project 4	Mortensen et al. (2016), Li et al. (2021), Zouhar et al. (submitted)	Project 3
22	Syllabification and syllable segmentation	Bartlett et al. (2009); Mayer (2010)	
23	Phonological similarity and cognate detection	Bharadwaj et al. (2016); Chaudhary et al. (2018)	
24	Phonological representations and phonological alternations	Barke et al. (2019)	
25	Sound change	Ceolin and Sayeed (2019)	
26	Rule ordering and relative chronology	Boldsen and Paggio (2022)	Project 4
	Presentations		
27	Presentations		

3 Motivation

The goal of this course is to **lead students to engage broadly with the existing NLP and computational linguistics research on subword modeling** and **develop new computational approaches to problems in morphology, orthography, and phonology**. In addition to three other miniprojects, students will be expected to produce one piece of research that can be developed into a conference or workshop paper (though submission is not a course requirement). The paper should be suitable for the "Phonology, Morphology, and Word Segmentation" tracks of the *ACL conferences, the SIGMORPHON workshop, Coling, or LREC.

Natural Language Processing and Computational Linguistics have traditionally been biased towards phenomenon above the level of the word: syntax, semantics, and discourse. Contemporary neural models have been very successful in modeling many of these phenomena using words or information-theoretically defined subword units as atomic tokens. However, this has left the structure and patterns that exist inside of words—at the level of morphology, orthography, phonology, and phonetics—relatively unexplored. Of course, there has been computational work in all of these fields for decades but they have never been given the same degree of attention as syntax, semantics, and discourse.

Now, as NLP and CL become increasingly multilingual, interest in languages with richer phonologies, orthographies, and morphologies than English and Chinese has grown. A new wave of research, informed by both linguistic theory and machine learning methods, has opened up novel perspectives on problems in this domain and both practical and scientific issues that have not previously been explored. This course aims to place students on this threshold, reading to make new contributions in this burgeoning subfield.

4 Learning Objectives

At the end of this course, students will:

- Express a sophisticated understanding of the fundamentals of morphology, phonetics, writing systems, and phonology
- Understand current papers in computational phonology, morphology, and orthography
- Implement current subword models of language and carry out publication-quality experiments in this area
- Write publication-quality papers reporting computational research in phonology, morphology, and orthography

5 Mode of Instruction

Class meetings will be structured around handouts (not slides), which will also double as lecture notes (the instructors preferred mode of instruction). This allows a freer and more fluid discussion of the course content than a regimented slide presentation. Furthermore, handouts can provide a rich source of material for student's subsequent reference.

6 Assessments

6.1 Highlights (10 pts)

For 25 of 27 class meetings, each students will submit a list of three highlights: two takeaways from the day's lecture and one question. These highlights are intended to be brief (one sentence each) and to encourage engagement with the lecture. These must be submitted by 11:59pm the day of the corresponding class meeting.

6.2 Projects (60 pts)

The course will be assessed primarily through four mini-projects. Three of the four projects are structured as shared tasks. Students are allowed to work individually or in pairs. All teams are presented with:

- A dataset (`train`, `dev`, and `test`; `test` labels are held out)
- A metric, an evaluation script, and an autograder for evaluation via Gradescope
- A baseline (usually implementing some of the linguistic insight presented in the lectures in a rule-based model)

Students receive full credit if they beat the baseline on the `text` set. If they achieve the highest score on the task, they receive 5 bonus points. Unlimited submissions are allowed.
The G2P project is structured differently (see §6.2.3 below).
To receive credit, for each project a student must submit a two page report (ACL template) describing their experiements and the results (as well as referencing earlier work that has inspired theirs).

6.2.1 Morphological Segmentation (15 pts)

dataset Segmented data from two languages (Rarámuri and Shipibo-Konibo).

task Given training and development sets, tag previously unseen words with morpheme boundaries.

metric F1

baselines WFST-based (rule based) segmenter, Unigram tokenization (students must beat both for all languages)

6.2.2 Reinflection and Paradigm Completion (15 pts)

Task 1

dataset Three typologically diverse languages from Unimorph

task Given training and development sets, a previously unseen lemma, and a set of inflectional properties, return the inflected form of the word

metric Exact match accuracy, character error rate

baseline Rule-based word-and-paradigm inflector

Task 2

dataset Three typologically diverse languages from Unimorph

task Given training and development sets and a previously unseen partial paradigm, predict the other wordforms in that paradigm

metric Exact match accuracy, character error rate

baseline Rule-based paradigm completion engine ("rules of referral")

6.2.3 G2P for Three Languages (15 pts)

Students are required to implement rule-based or data-driven G2P for a language not supported by Epitran2 within the Epitran2 framework (including tests). Students can opt to have their modules included in subsequent uses of Epitran2 and to become coauthors on the Epitran2 paper (in progress).

6.2.4 Cognate Detection (15 pts)

Cognates are words in two or more languages that are descended from the same word in their shared ancestor language (like English *brother* and German *Bruder*).

dataset Mortensen-Wagel Comparative Tangkhulic Database

task In an unsupervised or zero-shot fashion, identify all cognacy relations between words in the four related languages

metric Precison@5 (reference is gold cognacy judgments)

baseline Cosine similarity between mean-pooled phonological feature vectors with empirically-determined threshold

6.3 Final Presentation and Paper (30 pts)

Students will select one of their projects (or a different idea of their choosing), develop it into a potentially publishable research product and make a conference-style oral presentation of it to the class. This presentation will be evaluated both on its technical and scientific merit and on its communicative effectiveness. The same research will be written up as four- to eight-page research paper which will be evaluated generously based on its likelihood to be accepted by one of the target venues.

7 Grading

Grades will be assigned as follows:

Assessment	Points
Highlights	10
Mini-Projects	60
Final Project	30

The grading scale will be as follows:

Grade	Range	
A+	100%	to 94.0%
A	< 94.0%	to 90.0%
A-	< 90.0%	to 87.0%
B+	< 87.0%	to 84.0%
B	< 84.0%	to 80.0%
B-	< 80.0%	to 77.0%
C+	< 77.0%	to 74.0%
C	< 74.0%	to 70.0%
C-	< 70.0%	to 67.0%
D+	< 67.0%	to 64.0%
D	< 64.0%	to 61.0%
F	< 61.0%	to 0.0%

Highlights will be based on reasonable completion. Mini-projects will be based on meeting the base line for each challenge. Scores below the baseline will credited according to a linear function. The student with the highest score on each tasks will receive 5 bonus points. The final paper will be based on one of the four mini-projects. The deliverable will be a paper and presentation, which will be graded together according to the following criteria:

1. Is related work handled appropriately? (10%)
2. Is the methodology well-motivated and technically sound? (20%)
3. Are appropriate baselines employed? (15%)
4. Are the experiments well designed? (15%)
5. Does the analysis of the results follow accepted statistical practices? (10%)
6. Is the paper well-written? (15%)
7. Was the structure and presentation of the talk clear and effective (15%)

8 Policies

8.1 Academic integrity

Any cheating or plagiarism will be dealt with according to the University policies on academic integrity. In general, discussion of tools, concepts, and formalisms is acceptable collaboration and is encouraged. Misrepresenting the work of others as your own, however, is considered cheating.

8.2 Late Policy

This course works best when everybody completes their work by the designated deadlines. This prevents cascading tardiness from overwhelming both students and teaching staff. However, sometimes there are situations that call for extensions. Some examples (real examples) include the following:

- The death of friend or family member
- A wedding in the family
- A serious accident
- A surgery
- A significant illness
- A mental health crisis or episode
- An important religious or national holiday

We care about you and your well being more than we care about deadlines and if something difficult is happening in your life which is making it hard for you to complete an assignment on time **please contact the instructor so you can talk**. We have found that, often, the students who most need some leeway are those least likely to ask for it. It never hurts to ask. We will work out a plan so you can complete the requirements of the course with your physical and psychological health intact. **Do not feel ashamed to reach out to us.** We are eager to see you succeed.

8.3 Equity and Inclusion Policy

Throughout human history, some people have been denied the rights and opportunities available to others on the basis of their race, gender, economic class, caste, ancestry, language community, age, religion, beliefs, political affiliation, and abilities (visible and invisible). A single course cannot undo the injustices of history, but we—as a teaching staff—are committed to fighting inequity and promoting inclusion. We encourage you to join us. If you feel that you, or those around you, have been treated unfairly based upon their identity (or perceived identity) by us, by other members of the teaching staff, or by other students in the course, we ask that you bring it to our attention so that we can address the wrongs (as well as pursing the approved University channels).

8.4 Disability Rights

Many people have disabilities, including members of our own families. We see disabilities as deficits not in disabled people but in the institutions and societies that are structured such that they are disadvantaged. We wish to do our part to overcome this disparate treatment. If you have a disability (visible or invisible), please let us know as soon as possible (you don't need to tell us the nature of the disability) and work with Disability Service to develop a set of accommodations which we can then approve. These might, for example, include lecture materials that are usable by people with visual disabilities, sign language interpretation, captioning, flexible due dates, etc.

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