Parsing Greek morphology

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... in multiple dialects and alphabets

Digital scholarship and Classics

- 25 years ago: a leading discipline
- today: largely absent from new areas of textual analysis?

Example: latent pattern recognition

- topic modelling
- semantic relations with embedded word vectors

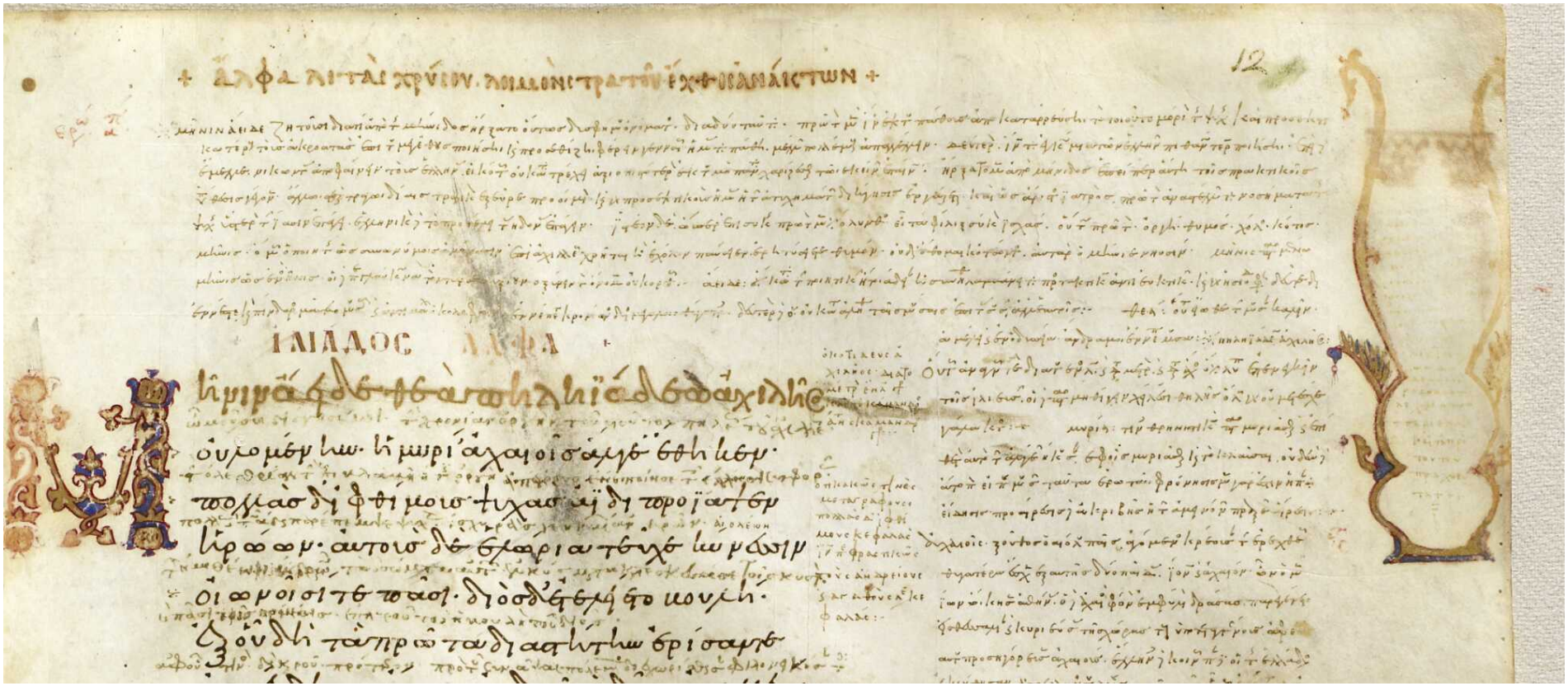
Some reasons, good and bad

- corpus size vs. tolerance for imprecise editions
- morphological complexity

Motivation

Homer Multitext project: manuscripts with

- multiple dialects
- unattested vocabulary
- distinct orthographies



Current standards

- ISO 639* family: Greek dialects not recognized
- Unicode:
  - language and script conflated
  - epichoric scripts not recognized
  - confusion of multivalent and contradictory glyphs

In 2017, it is (still!) not possible to encode Greek

Figure 2: A Vienna secession?

Secession, 1

Encode Greek in a *specified orthography*, including :

- encoding in (primarily) ASCII characters with distinct character for accent, breathing
- encoding in (primarily) Greek Unicode suitable for display

Encoding Greek

Literary Greek:

ἔδοξε == *e)/doce*

Pure diplomatic rendering of classical Attic:

εδοχσεν == *EDOXSEN*

Secession, 2

For historical languages, every analysis is corpus-specific

A corpus-linguistic perspective

Every corpus is characterized by:

- a unique lexicon in a specified orthography
- a unique set of inflectional rules in a specified orthography

So not *a parser*, but...

a system for building corpus-specific parsers

Citable results

- each lexicon entry has a unique ID for *lexical entity*
- each inflectional has a unique ID

“Greek” is defined by *analytical categories*

- “noun” (GCN)
- “adjective” (GCND)
- “conjugated verb” (PNTMV)
- “infinitive” (TV)
- “participle” (GCTMV)
- “verbal adjective” (GCN)
- “adverb” (Degree)
- “indeclinable” (part of speech)

An analysis is composed of

- a string of characters analyzed
- a form
- a uniquely identified lexical entity
- a uniquely identified inflectional rule

Kanónes

A system for building parsers from tables defining:

1. inflectional rules
2. a lexicon of “stems”

Parsing morphology

- standard technology: finite state transducers (FST)
- require context-free state transitions

Parsing Greek

FSTs fail!

> *Crossing of lexical and inflectional properties of accent cannot be reduced to context-free state transitions*

Solution in Kanónes

"Analysis by synthesis" algorithm:

1. collect an accented word
2. strip its accents, and use FST to get *possible* analyses
3. algorithmically apply correct accent
4. compare accented candidate forms to original word

Example parse

1. original word: εἶπε
2. εἰπε analyzed as:
    - 3rd singular aorist indicative active
    - 2nd singular aorist imperative active
3. accenting yields:
    - εἶπε for 3rd singular aorist indicative active
    - εἰπέ for 2nd singular aorist imperative active
4. so solution is 3rd singular aorist indicative active

A simple worked example: two parallel corpora

Andocides *On the Mysteries* 1.96

Νόμος. ἔδοξε τῇ βουλῇ καὶ τῷ δήμῳ.

IG 1.3, 156

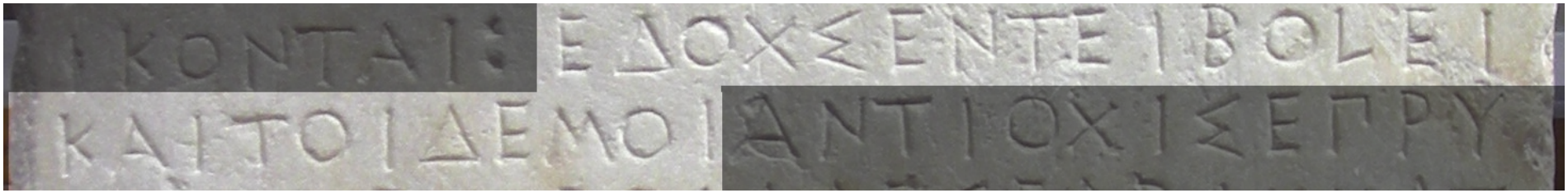


Figure 3: Decree honoring Leonides of Halicarnassus

Vocabulary (“stems”)

1	ID	Lexical entity	Stem	Gender	Inflection class	Accent class	Notes
2	vienna.att1_0	lexent.n1	BOL	fem	h_hs	inflacc	βολέ
3	vienna.att2_0	lexent.n2	DEM	masc	os_ou	stemacc	δêμος

Figure 4: Nouns, in Attic

1	ID	Lexical entity	Stem	Gender	Inflection class	Accent	Notes
2	vienna.n1_0	lexent.n1	boul	fem	h_hs	inflacc	βουλή
3	vienna.n2_0	lexent.n2	dhm	masc	os_ou	stemacc	δῆμος
4	vienna.n4_0	lexent.n4	nom	masc	os_ou	stemcc	νόμος

Figure 5: Nouns, in literary Greek

Inflectional rules

1	Rule	Inflection class	Ending	Gender	Case	Number
2	attnouninfl.h_hs3	h_hs	EI	fem	dat	sg
3	attnouninfl.os_ou3m	os_ou	OI	masc	dat	sg

Figure 6: Nouns, in Attic

1	Rule	Inflection class	Ending	Gender	Case	Number
2	nouninfl.h_hs3	h_hs	h|	fem	dat	sg
3	nouninfl.os_ou1m	os_ou	os	masc	nom	sg
4	nouninfl.os_ou3m	os_ou	w|	masc	dat	sg

Figure 7: Nouns, in literary Greek

Analysis

```
√ νόμος analyzed as noun, masculine, nominative, singular, from lexent.n6
√ ἔδοξε analyzed as verb, third, singular, aorist, indicative, active, from lexent.n3
√ τῇ analyzed as adjective, feminine, dative, singular, no degree, from lexent.n4
√ βουλῇ analyzed as noun, feminine, dative, singular, from lexent.n1
√ καί analyzed as indeclinable, conjunction, from lexent.n5
√ τῷ analyzed as adjective, masculine, dative, singular, no degree, from lexent.n4
√ δήμῳ analyzed as noun, masculine, dative, singular, from lexent.n2
```

Figure 8: literary Greek

Analysis

```
√ EDOXSEN analyzed as verb, third, singular, aorist, indicative, active, from
  lexent.n3
√ TEI analyzed as adjective, feminine, dative, singular, no degree, from lexent.n4
√ BOLEI analyzed as noun, feminine, dative, singular, from lexent.n1
√ KAI analyzed as indeclinable, conjunction, from lexent.n5
√ TOI analyzed as adjective, masculine, dative, singular, no degree, from lexent.n4
√ DEMOI analyzed as noun, masculine, dative, singular, from lexent.n2
```

Figure 9: Attic Greek

Generated

```
√ lexent.n6 in masculine, nominative, singular, generated as νόμος
√ lexent.n3 in third, singular, aorist, indicative, active, generated as ἔδοξε
√ lexent.n4 in feminine, dative, singular, no degree, generated as τῇ
√ lexent.n1 in feminine, dative, singular, generated as βουλῇ
√ lexent.n5 in indeclinable, conjunction, generated as καί
√ lexent.n4 in masculine, dative, singular, no degree, generated as τῷ
√ lexent.n2 in masculine, dative, singular, generated as δήμῳ
```

Figure 10: literary Greek

Pipeline

Output of Attic analysis fed as input to literary generator:

```
EDOXSEN -> ἔδοξε
TEI -> τῇ
BOLEI -> βουλῇ
KAI -> καί
TOI -> τῷ
DEMOI -> δήμῳ
```

Current state

- largely completed in 2016 using Stuttgart FST toolkit + Java/Groovy custom classes
- summer 2017: porting custom classes to Scala substantially complete
- initial test corpora from HMT project:
  - complete *Iliad* manuscripts
  - more than 10,000 scholia

Possibilities

- morphologically sensitive structured searching
- lexically unified corpus for latent pattern analysis
- integration of corpora in distinct writing systems or dialects

Thank you!

For more information:

- "Morphological Analysis of Historical Languages," *BICS* 59-2 (2016) 89-102.
- `https://github.com/neelsmith/kanones`