Finite-state morphological transducers for three Kypchak languages

Jonathan North Washington
Indiana University
jonwashi@indiana.edu

Ilnar Salimzyanov
Казан (Идел буе) федераль университеты
ilnar.salimzyan@gmail.com

Francis M. Tyers
UiT Norgga Árktalaš Universitehta
francis.tyers@uit.no

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Aida Sundetova
sun27aida@gmail.com

- Turkic languages (SOV, agglutinative, vowel harmony)

	Kazakh /qazaq/	**Tatar** /tɤtar/	**Kumyk** /qumuq/
population of speakers			
number	8M-12M	5.4M	430K
primary	Kazakhstan	Tatarstan	Dagestan
secondary	China, Mongolia	Bashqortostan	?
external influences			
Mongolic	moderate	light	light
Oghuz	—	light	moderate
Persian	heavy	heavy	heavy
Russian	heavy	heavy	heavy

Morphological transducers

- Take a surface form, and produce valid lexical form(s)
- Take a lexical form, and produce valid surface form(s)

‘алдым’ ↔ `ал<v><tv><ifi><p1><sg>`, `алд<n><px1sg><nom>`

Transducers for Turkic languages

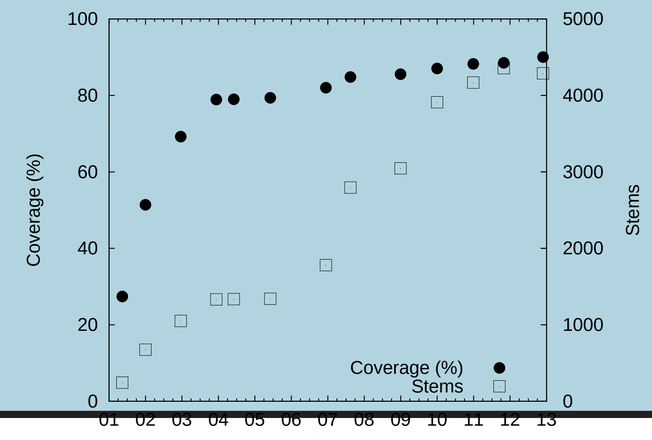
- Turkish (Çöltekin, 2010; Öflazer, 1994)
- Crimean Tatar (Altıntaş, 2001)
- Turkmen (Tantuğ et al., 2006)
- Kyrgyz (Tyers et al., 2012)
- GPL (=free and open)!

Framework: HFST

- Reimplementation of Xerox FST formalisms (`lexc` and `twol`)
- Also provides a wrapper around popular free/open-source FST toolkits: SFST, OpenFST, and Foma

Development effort

- Kumyk transducer based on Kazakh & Tatar transducers
- ±1 week to reach 80% coverage, +1 week to reach 90%



Morphological & orthographical words

- өнүктүрөбүзбү ? *‘will we develop [it]?’*
  `өнүк<v><tv><caus><aor><p1><pl>+бы<qst>`
- келатсаң *‘if you come’*
  `кел<v><iv><prt_impf>+жат<vaux><gna_cnd><p2><sg>`

```
LEXICON N-INFL-3PX-COMPOUND
%<n%>:%>%{S%}%{I%}%{n%} GEN-POS ;

LEXICON Nouns
аба% ырайы:аба% ырай N-INFL-3PX-COMPOUND ;
                                  ! ”weather”
чакыруу% кагазы:чакыруу% каглз N-INFL-3PX-
                        COMPOUND ; ! ”invitation”
```

Gloss

(1) Аллагь Оьзю яратгъан затлагъа къарап, олар бек яхшы экенин гёрген.
Аллаһ Үзе яраткан нәрсәләргә карап, аларның бик яхшы икәнен күрде.
Құдай Өзінің жаратқандарының бәріне қарап, өте жақсы екенін көрді.
God own-his created [everything/thing-s]-to looked.at, they/their very good being saw.

‘God looked at everything he had created and saw that it was very good.’

Output

Kazakh (kaz)

```
Құдай өзінің жаратқандарының
бәріне қарап, өте жақсы екенін көрді.
```

```
Құдай<n><nom>
Өз<prn><ref><px3sp><gen>
жарат<v><tv><ger_past><pl><px3sp><gen>
бәрі<prn><qnt><px3sp><dat>
қара<v><tv><gna_perf>
,<cm>
—
өте<adv>
жақсы<adj>
е<cop><ger_past><px3sp><acc>
көр<v><tv><ifi><p3><sg>
.<sent>
```

Tatar (tat)

```
Аллаһ Үзе яраткан нәрсәләргә карап,
аларның бик яхшы икәнен күрде.
```

```
Аллаһ<n><nom>
Үз<prn><ref><px3sp><nom>
ярат<v><tv><gpr_past>
нәрсә<prn><itg><pl><dat>
кара<v><tv><gna_perf>
,<cm>
алар<prn><pers><p3><pl><gen>
бик<adv>
яхшы<adj>
и<cop><ger_past><px3sp><acc>
күр<v><tv><past><p3><sg>
.<sent>
```

Kumyk (kum)

```
Аллагь Оьзю яратгъан затлагъа
къарап, олар бек яхшы экенин гёрген.
```

```
Аллагь<n><nom>
Оьз<prn><ref><px3sp><nom>
ярат<v><tv><gpr_past>
зат<n><pl><dat>
къара<v><tv><gna_perf>
,<cm>
олар<prn><pers><p3><pl><nom>
бек<adv>
яхшы<adj>
э<cop><ger_past><px3sp><acc>
гёр<v><tv><past><p3><sg>
.<sent>
```

Tagset

`<n>`	Noun	`<p3>`	Third person	`<ref>`	Reflexive	`<px3sp>`	3rd person poss. (Singular/Plural)
`<v>`	Verb	`<pl>`	Plural	`<pers>`			
`<prn>`	Pronoun	`<nom>`	‘Nominative’	`<cm>`	Comma	`<ger_past>`	Verbal noun (Past)
`<det>`	Determiner	`<gen>`	Genitive	`<sent>`	Sentence	`<gna_perf>`	Verbal adverb (Perfect)
`<adj>`	Adjective	`<acc>`	Accusative	`<past>`	Past (General)		
`<adv>`	Adverb	`<dat>`	Dative	`<ifi>`	Past (Eyewitness/Recent)	`<gpr_past>`	Verbal adjective (Past)
`<iv>`	Intransitive	`<qnt>`					
`<tv>`	Transitive	`<itg>`	Interrogative				

Desonorisation

- {N} desonorises to д after a consonant
  алма-{N}{I} → алманы ‘*apple*–ACC’
  сыр-{N}{I} → сырды ‘*secret*–ACC’
- {L} desonorises to д after cons. of sonority ≤ /l/
  сыр-{L}{A}р → сырлар ‘*secret*–PL’
  кыз-{L}{A}р → кыздар ‘*girl*–PL’

```
”L Desonorisation”
%{L%}:д <=> :VoicedLowSonCns %>: __ ;

”N Desonorisation”
%{N%}:д <=> :VoicedCns %>: __ ;
```

Lenition

- Turn {y} into a harmonised high vowel when a vowel doesn’t follow the following consonant:
  мур{y}н → мурун ‘*nose*’
  мур{y}н+{I}м → мурдум ‘*my nose*’

```
%{y%}:Vy <=> [ :LastVowel :Cns* :Cns ]/[:0] __
          [ :Cns [ .#. | :Cns ] ]/[ :0 | %>:] ;
 where Vy in ( и ү и и ү ы ы у у ы у у )
LastVowel in ( и ү е э ө я а ё о ы ю у )
            matched ;
```

й+vowel letters

- [а о у] become [я ё ю] after й and й deletes
- й incorporated into the context of many rules
- + separate rules to change the characters
- + a rule to delete the original й

```
”Deletion of й before yoticised vowels”
й:0 <=> __ [ :YotVow ]/[ :0 | %>: ] ;
```

- Part of Apertium Turkic project:
  `http://wiki.apertium.org/wiki/Apertium_Turkic`
- Transducers available live at turkic.apertium.org
- Source code available from apertium’s svn repo
- Turkic RBMT mailing list (>25 subscribers):
  `apertium-turkic@lists.sourceforge.net`
  Feel free to post in any language!
- See our paper in the LREC 2014 proceedings
- And feel free to contact the authors any time!

Number of stems

Part of speech	**Number of stems** Kazakh	Tatar	Kumyk
Noun	2640	2795	2568
Verb	1470	1143	386
Adjective	754	816	219
Proper noun	5701	5361	1443
Adverb	171	177	63
Numeral	63	63	44
Conjunction	46	45	13
Postposition	50	43	12
Pronoun	32	28	17
Determiner	39	34	9
Total:	11224	10737	4845

Test corpora

type	**lang**	**contents**
Encyclopædic	kaz	Wikipedia
	tat	Wikipedia
	kum	—
News	kaz	RFE/RL (azattyq.org)
	tat	tat.tatar-inform.ru
	kum	Ёлдаш (yoldash.etnosmi.ru)
Religion	kaz	Quran + Bible
	tat	Quran + New Testament
	kum	Genesis + New Testament

- split into 10 equal parts; coverage calculated over each separately; standard deviation of mean calculated

Coverage measures

- **Naïve coverage** - percentage of surface forms in a given corpus receiving ≥ 1 analysis (surface forms may have missing analyses)
- **Mean ambiguity** - average number of analyses for each surface form found in analysed corpus

Coverage results (as of r36739)

Language	**Corpus**	**Tokens**	**Coverage** (%)
Kazakh	Wikipedia	25.6M	85.61 ± 1.37
	News	3.8M	92.12 ± 2.72
	Religion	851K	92.49 ± 1.66
	Average	—	90.07 ± 1.91
Tatar	Wikipedia	159K	86.35 ± 2.17
	News	5.2M	89.75 ± 0.07
	Religion	382K	91.25 ± 2.55
	Average	—	89.12 ± 1.60
Kumyk	Wikipedia	—	—
	News	286K	91.10 ± 0.86
	Religion	227K	92.47 ± 1.03
	Average	—	91.78 ± 0.94

Precision & recall

- selected 1000 surface forms at random from RFE/RL corpus, proof read analyses
- **Precision** (of a form’s analyses % correct): **97.32%**
- **Recall** (percentage of analyses provided by the transducer that are correct for a form, by comparing against a gold standard): **94.56%**