Finite-state morphological transducers for three Kypchak languages

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- 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

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>

Irregular [noun + possessive + case] forms

- Some combinations of possessive and case morphemes are distinct (i.e., not formed simply by concatenation):

case	form	1SG	2SG	3SP
nom	—	-(I)м	-(I)ң	-(S)I
acc	-NI	-(I)мдI	-(I)ңдI	**-(S)Iн**
gen	-NIн	-(I)мдIн	-(I)ңдIн	-(S)IнIн
loc	-DA	-(I)мдA	-(I)ңдA	**-(S)IндA**
abl	-DAн	-(I)мдAн, **-(I)мAн**	-(I)ндAн, **-(I)ңAн**	**-(S)IнAн**
dat	-GA	**-(I)мA**	**-(I)ңA**	**-(S)IнA**

- Trade-off:
  - morphophon. complicateder, morphotactics simpler
  - underlying form used: `{S}{I}{n}`
  - phonological rules delete `{n}`, `{S}` by context

Noun-noun compounds

- one type of N-N compunds: N2 has <px3> and related morphology

```
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% кагаз N-INFL-3PX-
                        COMPOUND ; ! ”invitation”
```

Gloss

(1) Аллагь Оьзю яратгъан затлагъа къарап, олар бек яхшы экенин гёрген.
God own-his made thing-s-to look-having, they very good being saw.
‘God looked at everything he had made and saw that it was very good.’

Output

Kazakh	Tatar	Kumyk
Құдай өзінің жаратқандарының бәріне қарап, өте жақсы екенін көрді.	Аллаһ Үзе яраткан нәрсәләргә карап, аларның бик яхшы икәнен күрде.	Аллагь Оьзю яратгъан затлагъа къарап, олар бек яхшы экенин гёрген.
Құдай<n><nom>	Аллаһ<n><nom>	Аллагь<n><nom>
өз<prn><ref><px3sp><gen>	Үз<prn><ref><px3sp><nom>	Оьз<prn><ref><px3sp><nom>
жарат<v><tv><ger_past><pl><px3sp><gen>	ярат<v><tv><gpr_past>	ярат<v><tv><gpr_past>
бәрі<prn><qnt><px3sp><dat>	нәрсә<prn><itg><pl><dat>	зат<n><pl><dat>
қара<v><tv><gna_perf>	кара<v><tv><gna_perf>	къара<v><tv><gna_perf>
,<cm>	,<cm>	,<cm>
—	алар<prn><pers><p3><pl><gen>	олар<prn><pers><p3><pl><nom>
өте<adv>	бик<adv>	бек<adv>
жақсы<adj>	яхшы<adj>	яхшы<adj>
е<cop><ger_past><px3sp><acc>	и<cop><ger_past><px3sp><acc>	э<cop><ger_past><px3sp><acc>
көр<v><tv><ifi><p3><sg>	күр<v><tv><past><p3><sg>	гёр<v><tv><past><p3><sg>
.<sent>	.<sent>	.<sent>

Tagset

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

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%**