Transliterating Urdu for a Broad-Coverage Urdu/Hindi LFG Grammar

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Contents of the Talk:

1. Context of Work – the ParGram Project
2. Urdu & Challenges in Transliterating Urdu
3. Transliterator Architecture
4. Integrating the Transliterator in the ParGram Urdu Grammar
Context of Work

- Computational LFG grammar in development in Konstanz
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- Aim: large-scale LFG grammar for parsing Urdu/Hindi
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  - Languages involved:
    → large-scale: English, German, French, Japanese, Norwegian
    → smaller-scale (yet...): Welsh, Georgian, Hungarian, Turkish, Chinese, Urdu (among many others)
The ‘Parallel’ in ParGram

Analysis for transitive sentence in English ParGram grammar (F-Structure, “Functional Structure”):
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"Nadya saw the book."

```
PRED 'see<[1:Nadya], [113:book]>'
  PRED 'Nadya'
  CHECK [LEX-SOURCE:morphology _PROPER:known-name]
  SUBJ NTYPE NSEM [PROPER [NAME-TYPE:first_name] PROPER-TYPE:name]
    NSYN proper
    1 | CASE: nom, GEND-SEM:female, HUMAN: +, NUM: sg, PERS: 3
    OBJ NTYPE NSEM [COMMON:count]
      NSYN common
      SPEC [DET [PRED 'the']]
      113 | CASE: obl, NUM: sg, PERS: 3
      CHECK [SUBCAT-FRAME:SUBJ-OBJ]
      TNS-ASP [MOOD: indicative, PERF: --, PROG: --, TENSE: past]
      57 | CLAUSE-TYPE:decl, PASSIVE: -, VTYPE: main
```
The ‘Parallel’ in ParGram (cont.)

Analysis for the same transitive sentence in Urdu ParGram grammar (F-Structure, “Functional Structure”):
The ‘Parallel’ in ParGram (cont.)

Analysis for the same transitive sentence in Urdu ParGram grammar (F-Structure, “Functional Structure”):

"nAdiyah nE kitAb dEkHI"

```
PRED 'dEkH<[1:nAdiyah] [19:kitAb>}'
PRED 'nAdiyah'
CHECK ['NMORPH obl']

SUBJ NTYPE [NSEM [PROPER [PROPER-TYPEname]]
          [NSYN proper]
          [sem-prop [SPECIFIC +]]
          CASE erg, GEND fem, NUM sg, PERS 3
          PRED 'kitAb'

OBJ NTYPE [NSEM [COMMON count]]
          [NSYN common]
          CASE nom, GEND fem, NUM sg, PERS 3
          CHECK ['VMORPH [_MTYPE inf]
                _RESTRICTED-, _VFORM perf']
          LEX-SEM [AGENTIVE +]
          TNS-ASP [ASPECT perf, MOOD indicative]
          CLAUSE-TYPE decl, PASSIVE -, VTYPE main
```
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Analysis for the same transitive sentence in Urdu ParGram grammar (F-Structure, “Functional Structure”):

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→ Analyses are kept parallel where possible
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→ Features are kept parallel where possible
Urdu

Urdu is
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- descended from (a version of) Sanskrit (sister language of Latin)
- structurally identical to Hindi (spoken mainly in India)
- together with Hindi the fourth most spoken language in the world (≈ 250 million native speakers)
Two Scripts, One Language

- While Urdu uses an Arabic-based script, Hindi uses Devanagari.
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- The same couplet by the poet Mirza Ghalib in both of the scripts:
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  **Urdu**
  
  پان بھلا کرتا بھلا ہوگا
  اور وہیں کی صدکیاں بے

  **Hindi**
  
  हां भला कर तिरा भला होगा
  और दर्वेश की सदा कूया है
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  پان جہلا کر ترا جہلا تورگا
  اور وروشین کی سدایا بے

  **Hindi**
  
  हां भला कर तिरा भला होगा
  और दर्वेश की सदा क्या है

- **Common transliteration in Latin alphabet:**
  
  hAN bHaIa  kAR tirA  bHaIa  hOgA
  yes  good. M. Sg  do  then  good  be. Fut. M. Sg
  Or  darvES kI  sadA  kyA  he
  and dervish  Gen. F. Sg  call. F. Sg  what  be. Pres. 3. Sg

  ‘Yes, do good then good will happen, what else is the call of the dervish.’
Abstracting Away from the Scripts

- Faced with 2 possibilities:
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- Encode a *single grammar and lexicon* in ASCII-based transliteration
Abstracting Away from the Scripts

- Urdu Script
- Hindi Script
- Common ASCII-based Transliteration
- Computational LFG Grammar
Abstracting Away from the Scripts

- Urdu Script
- Hindi Script

Common ASCII-based Transliteration

Computational LFG Grammar

→ Size of the lexicon is kept minimal
Abstracting Away from the Scripts

→ Size of the lexicon is kept minimal
→ Grammar development effort is kept minimal
The Urdu Script: Some Peculiarities

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- Extensive borrowing from Arabic and Persian
The Urdu Script: Some Peculiarities

- Uses extended Arabic character set
- Full letters for consonants/long vowels, Aerabs (diacritics) for short vowels
- Written Urdu: Aerab diacritics are not common
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  - Foreign spelling retained in written Urdu
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- Extensive borrowing from Arabic and Persian
  - Foreign spelling retained in written Urdu
  - Arabic and Persian graphemes map onto a single Urdu phoneme
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  2. Dual (Consonant and Vocalic) Characters, e.g. →/j/ or /æ/
Urdu & Challenges in Transliterating Urdu

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  3. A Vowel Modifier Character: ﺔ → /~/
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  1. Simple Consonant Characters, e.g. \( \text{ف} \rightarrow /f/ \)
  2. Dual (Consonant and Vocalic) Characters, e.g. \( \text{ج} \rightarrow /j/ \) or \( /\text{ae}/ \)
  3. A Vowel Modifier Character: \( \text{ن} \rightarrow /\sim/ \)
  4. A Consonant Modifier Character: \( \text{ہ} \rightarrow /h/ \)
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  1. Simple Consonant Characters, e.g. ﬂ → /f/
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  3. A Vowel Modifier Character: ئ → /~/
  4. A Consonant Modifier Character: ئ → /ʰ/

- For classes (1), (3) and (4), the mapping from graphemes to phonemes is one-to-one: a simple rule-based model can be developed
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- Urdu has 4 different character classes:
  1. Simple Consonant Characters, e.g.  zab/ → /f/
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- For class (2), context-sensitive rules were designed to account for the dual behavior.
### The Urdu Script: Some Peculiarities

An excerpt from our scheme table:

<table>
<thead>
<tr>
<th>Unicode Urdu character</th>
<th>Latin letter in transliteration scheme</th>
<th>Phoneme</th>
</tr>
</thead>
<tbody>
<tr>
<td>ﺝ</td>
<td>b</td>
<td>/b/</td>
</tr>
<tr>
<td>ﺝ</td>
<td>p</td>
<td>/p/</td>
</tr>
<tr>
<td>ﺝ</td>
<td>t</td>
<td>/t/</td>
</tr>
<tr>
<td>ﺝ</td>
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</tr>
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The Transliterator Pipeline

Input: Unicode Urdu Text

STEP 1: Normalization

STEP 2: Diacritization

STEP 3: Unicode to Urdu Zabta Takhti Conversion

STEP 4: Transliteration

Output: ASCII-based Scheme Transliteration
STEP 1: Normalization

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    - *Alef madda*: \( \text{ā} \)
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  - *decomposed form*: combined out of 2 or more characters:
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- Unicode Arabic script: characters can be written in 2 ways
  - Composed form: as a single entity in Unicode block:
    - Alef madda: \( \text{\textbar} \) \( \text{\check{a}} \)
  - Decomposed form: combined out of 2 or more characters:
    - Alef: \( \text{\textbar} \) \( \text{a} \)
STEP 1: Normalization

Unicode Arabic script: characters can be written in 2 ways
- *Composed form*: as a single entity in Unicode block:
  \[\text{Alef madda}: \tilde{\imath} \quad \ddot{a}\]
- *decomposed form*: combined out of 2 or more characters:
  \[\text{Alef}: \quad \tilde{\imath} \quad a\]
  + lengthening diacritic *madda*: \[\hat{a}\]
STEP 1: Normalization

- Unicode Arabic script: characters can be written in 2 ways
  - *Composed form*: as a single entity in Unicode block:
    \[ \text{Alef madda: } \overset{\sim}{\vspace{3pt}} \tilde{\alpha} \]
  - *decomposed form*: combined out of 2 or more characters:
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- To avoid a duplication of rules, the input text is normalized to composed character form
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→ The system works on composed characters only!
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  - Urdu lexicon data (80,000 diacritized words - gathered by CRULP in Lahore)
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→ Ambiguity created by absence of aerab diacritics is resolved
STEP 3: Unicode to Urdu Zabta Takhti Conversion

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**Example:**

Urdu Unicode text

\[\vAHH d\HHd \text{‘key’}\]

UZT–converted text

898083120

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STEP 4: Transliteration

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Example:

UZT–converted text
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transliterated Latin letter-based notation
cAbI čabī 'key'
STEP 4 (cont.): Transliteration of Loan Graphemes

- Loan words from Arabic and Persian include graphemes from these languages
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- Solution: Map genuine Urdu letter to general letter $s$; map foreign variants to $s_2$, $s_3$ etc.
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\text{ص} , \text{ث} , \text{س} \quad \rightarrow \quad /s/
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- Borrowed characters: 
  \( ص، ث \rightarrow s_2, s_3 \)
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\]

- Most common, genuine Urdu character: س $\rightarrow$ $s$
- Borrowed characters: ص $\rightarrow$ $s_2$, $s_3$

→ Lexicon is kept simple to read in most of the cases
Evaluation of the Transliterator

- 1000 high frequency words collected from 18 million word Urdu corpus
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- Performance of the transliterator:

<table>
<thead>
<tr>
<th>Test Corpus Size</th>
<th>$A = \frac{C_w}{T_w}$ (diacritized input)</th>
<th>$A = \frac{C_w}{T_w}$ (input without diacritics, with foreign words)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1000</td>
<td>0.995</td>
<td>0.925</td>
</tr>
</tbody>
</table>

Table: Accuracy Results for Transliterator
The Architecture of the Grammar

The transliterator is integrated into a parsing architecture using a Finite-State Morphological Transducer (FSMT) and the XLE Grammar Development Platform (XLE).
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Transliterator (Urdu & Hindi Unicode to ASCII-Based Transliteration) ↓
Tokenizer ↓
Morphology (FSMT) ↓
Syntax (C- and F-Structure) (XLE)
Integrating the Transliterator

→ Transliterator applies first
Integrating the Transliterator in the ParGram Urdu Grammar

Integrating the Transliterator

→ Transliterator applies first

Example (gARI call ‘The car worked/started.’)

transliterator input:

غڑی چالی
gāṛī ḍālī
gari  căli

transliterator output:

gāṛī ḍālī
gari  căli
Integrating the Transliterator (cont.)

→ Transliterator output feeds in XLE tokenizer
Integrating the Transliterator (cont.)

→ Transliterator output feeds in XLE tokenizer

Example (gARI call ‘The car worked/started.’)

tokenizer input:
gARI calI  

gARI TB calI TB

tokenizer output:
gārı́ čalī  
gārı́ čalī
Integrating the Transliterator (cont.)

→ Transliterator output feeds in XLE tokenizer

Example (gARI call ‘The car worked/started.’)

tokenizer input:
gARI calI

tokenizer output:
gARI TB calI TB

→ Tokenizer output feeds in FST morphological transducer
Integrating the Transliterator (cont.)

→ **Transliterator output feeds in XLE tokenizer**

Example (*gARI call* ‘The car worked/started.’)

tokenizer input:
gARI calI
gārī  călī
tokenizer output:
gARI TB calI TB
gārī  călī

→ **Tokenizer output feeds in FST morphological transducer**

Example (*gARI call* ‘The car worked/started.’)

morphology output:
gARI+Noun+Fem+Sg
gārī
calI+Verb+Perf+Fem+Sg
călī
Integrating the Transliterator (cont.)

→ Morphology output feeds in XLE syntactic rules
Integrating the Transliterator (cont.)

→ Morphology output feeds in XLE syntactic rules

Example (*gARI call* ‘The car worked/started.’)

Morphology Output/Syntax input:
gARI+Noun+Fem+Sg

calI+Verb+Perf+Fem+Sg

Syntax output (C-Structure and F-Structure):

```
gARI
g.ı

calI
ˇcalı

CS 1: ROOT
        S
          KP VCmain
            NP V
              N calI
                gARI

"gARI calI"

[ PRED 'cal<1:GAR>'
  PRED 'gAR'
  SUBJ NTYPE [NSEM [COMMON count]]
    NSYN common
      1 CASE nom, GEND fem, NUM sg, PERS 3
  CHECK _VMORPH [
    _MTYPE infi
    _RESTRICTED _, _VFORM perf
  ]
  LEX-SEM [AGENTIVE -]
  TNS-ASP [ASPECT perf, MOOD indicative]
  CLAUSE-TYPE decl, PASSIVE -, VTYPE main
]```
References


Thank you!

Are there questions?