Recent Advances in the Hindi/Urdu LFG Grammar

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Introduction

ParGram ("Parallel Grammar"): NLP project based on Lexical Functional Grammar (LFG)

- multilingual grammar development project
- large-scale, robust, parallel computational grammars
- so far:
  - larger grammars for English, German, French, Norwegian, Chinese and Japanese
  - smaller grammars for Bahasa Indonesian, Malagasy, Turkish and Welsh
- (recently: ParSem — extends ParGram approach to multilingual, parallel semantics)

Introduction

Possible Applications:

- Machine Translation (made simpler because of deep analysis and parallelism across languages).
- Text Summarization (*parsing* of large corpora, *generation* of summaries)
- Question-Answer Systems (*parsing* of large corpora, *generation* of answers) — successful company built on this (Powerset).

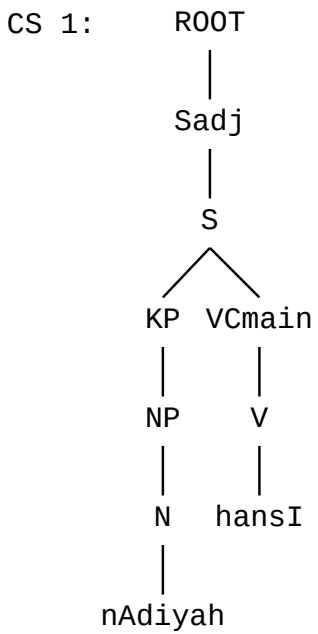
Introduction

Advantages of the ParGram Approach:

- LFG allows for a modular architecture:
  - morphology, syntax and semantics are encoded at independent levels providing necessary flexibility
  - each level of analysis uses different types of representations (e.g., trees vs. AVMs vs. logical formula)
  - all of the levels interact, accounting for interactions across modules
  - an LFG grammar is *reversible*: a grammar can be used for **both** parsing and generation

C- and F-Structure

Example: Analysis from our Urdu grammar for the sentence *naadiyah hansii*

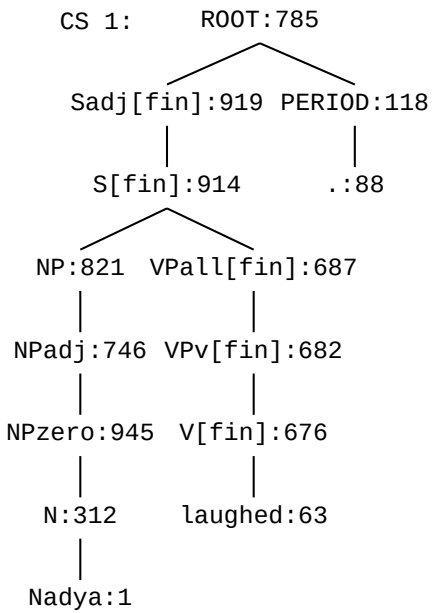


"nAdiyah hansI"

```
[PRED    'hans<[1:nAdiyah]>'
 SUBJ 1  [PRED     'nAdiyah'
          NTYPE    [NSEM [PROPER [PROPER-TYPE name]]
                    NSYN proper]
          SEM-PROP [SPECIFIC +]
          CASE nom, GEND fem, NUM sg, PERS 3]
 CHECK    [_VMORPH [_MTYPE infl]
           _RESTRICTED -, _SUBCAT-FRAME V-SUBJ, _VFORM perf]
 LEX-SEM  [VERB-CLASS unerg]
 TNS-ASP  [ASPECT perf, MOOD indicative]
 CLAUSE-TYPE decl, PASSIVE -, VTYPE main 19]
```

C- and F-Structure

Example: Analysis from the English ParGram grammar for the sentence *Nadya laughed*



"Nadya laughed."

```
⎡PRED     'laugh<[1:Nadya]>'                                                    ⎤
⎢         ⎡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                  ⎦⎥
⎢CHECK    [_SUBCAT-FRAME V-SUBJ]                                               ⎥
⎢TNS-ASP  [MOOD indicative, PERF -_, PROG -_, TENSE past]                      ⎥
⎣      63 CLAUSE-TYPE decl, PASSIVE -, VTYPE main                              ⎦
```

ParGram

Advantages of the ParGram Approach:

- The "parallel" in ParGram means:
  - Analyses should abstract away from language particular features as much as possible.
  - A common set of grammatical features is chosen based on common decisions across a range of differing languages.
  - The in-built multilingual perspective means one avoids pitfalls & shortcomings often found in monolingual NLP efforts.

ParGram

Particulars of Grammar Development

- XLE Grammar Development Platform (available by license from PARC)
- integrates: tokenizer (FST), morphological analyzer (FST), syntactic rules (LFG), transfer component (Prolog rewriting rules) used for machine translation and semantic construction
- XLE is written in C; powerful & efficient

Hindi/Urdu grammar at Konstanz

- A small Hindi/Urdu grammar had already been developed at Konstanz.
- Hindi/Urdu is the only South Asian language within ParGram; interesting from a typological point of view.
- **Research Question:** Can the existing small grammar be scaled up to a robust and large-scale grammar within the ParGram context?
- **Some Challenges:**
  - Massive use of complex predicates (about 30% of any text)
  - Free Word-Order, dropping of arguments (problem for generation)
  - Complex interaction between morphology, syntax and semantics (e.g., tense/aspect, case marking, reduplication, Ezafe construction)

Existing Resources

- Much work on some necessary basic resources has been done — most of it at CRULP (fonts, corpora, dictionaries, POS-taggers, etc.)
- Some morphological analyzers have been worked on — however, while in principle these are stand-alone systems, the ParGram context assumes certain types of analyses. So we had to build our own.
- CRULP has worked on an LFG-based Urdu grammar. However, it was designed for parsing, not generation, so did not deal with word order or dropped arguments.

Urdu grammar at Konstanz

Therefore: project on scaling up the existing small Konstanz Hindi/Urdu grammar and developing additional tools.

- 3 years of funding
- official start date: March 1st, 2009
- official end date: February 29th, 2012
- goals: reach broad coverage for Hindi/Urdu grammar (both parsing and generation); develop lexical resources; build semantics module
- this talk: progress in reaching first goal...

The Urdu NP

- progress with respect to NP-internal structure
- word order of Urdu NP is subject to variation
- new NP rule implementation allows for these variations, using two XLE-internal tools: *shuffle operator*, *head precedence operator*

NP Word Order

- valid Urdu NPs; equivalent in meaning:

(1) a. sadr =ko haasil muqaddamaat =se istisnaa
president.M.Sg Dat possessed court-cases.M.Pl Abl immunity.M.Sg
'the immunity from court-cases possessed by the president' rare

b. muqaddamaat =se sadr =ko haasil istisnaa
court-cases.M.Pl Abl president.M.Sg Dat possessed immunity.M.Sg
'the immunity from court-cases possessed by the president' more often

c. sadr =ko muqaddamaat =se haasil istisnaa
president.M.Sg Dat court-cases.M.Pl Abl possessed immunity.M.Sg
'the immunity from court-cases possessed by the president' common

- despite differing word order, internal structure is identical:
  - *haasil* takes *sadr =ko* as argument
  - *sadr =ko haasil* modifies *istisnaa*
  - *istisnaa* takes *muqaddamaat =se* as argument

NP Word Order

Closer look at example (1) c.:

sadr =ko muqaddamaat =se haasil istisnaa
president.M.Sg Dat court-cases.M.Pl Abl possessed immunity.M.Sg
'the immunity from court-cases possessed by the president'

- *sadr ko*, argument of haasil is not adjacent to it
- AP *sadr ko haasil* 'possessed by the president' is a constituent, but its elements are discontinuous
- we find a non-member *muqaddamaat se* between its elements
- arguments of both the noun and its adjective are stacked together irrespective of the logical hierarchical structure

Possible Generalizations

- Generalization #1: Word order is fairly free
- Generalization #2: Arguments must precede their heads

(2) a. *haasil muqaddamaat =se sadr =ko istisnaa
possessed court-cases.M.Pl Abl president.M.Sg Dat immunity.M.Sg

b. *sadr =ko haasil istisnaa muqaddamaat =se
president.M.Sg Dat possessed immunity.M.Sg court-cases.M.Pl Abl

→ **overall, evidence for flat c-structure tree**

→ **at f-structure, associate arguments with their heads based on case/postposition requirements of heads**

Outline of Implementation

Currently, the Urdu NP structure is implemented using two XLE-internal operators:

1. *Shuffle operator:* `[ XP , XP ]`

- items separated by the operator are "shuffled"
- allows the items to occur in any order
- relative order of elements is preserved if no operator is given

```
[A B] , [X Y]

A B X Y
A X Y B
X A Y B
A X B Y
X A B Y
X Y A B
```

Outline of Implementation

Excerpt from NP rule (simplified, without functional annotation):

```
NP -> KP*          e.g.  sadr =ko, muqaddamaat =se
      ,            shuffle operator
      PP*
      ,
      (Aord)
      ,
      AP*          e.g.  haasil (attributive adjectives)
      Nmod         for compounds
      N            e.g.  istisnaa (NP head)
      ,
      (CPrel).
```

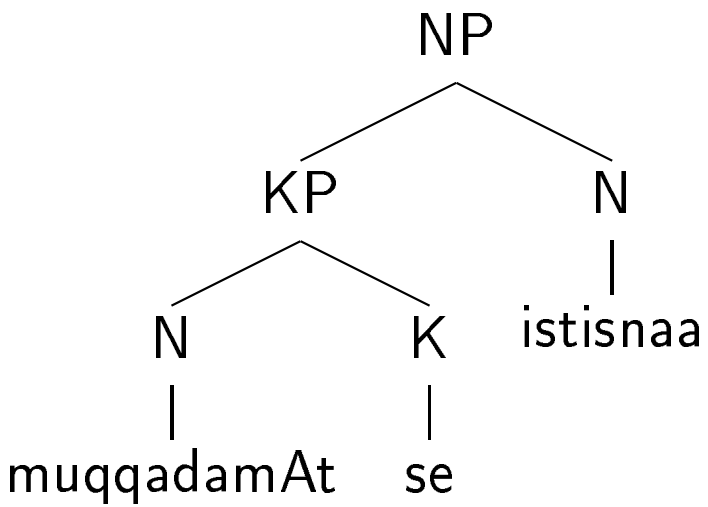
Outline of Implementation

2. *Head precedence operator:* [`f1` >`h` `f2`]

- relation between two (partial) f-structures
- both f-structures must have heads
- head of f2 must precede the head of f1 *in the c-structure tree*
- word associated with head of f2 must precede word associated with head of f1

Outline of Implementation

Example: (ˆ SUBJ) >h (ˆ SUBJ $ OBL)



$$\begin{bmatrix} \text{SUBJ} \begin{bmatrix} \text{PRED } \text{`istisnaa<(}\uparrow \text{ OBL)>'} \\ \text{OBL } \begin{bmatrix} \text{PRED } \text{`muqqadamAt'} \end{bmatrix} \end{bmatrix} \end{bmatrix}$$

→ head of `OBL` must precede head of `SUBJ`!

Outline of Implementation

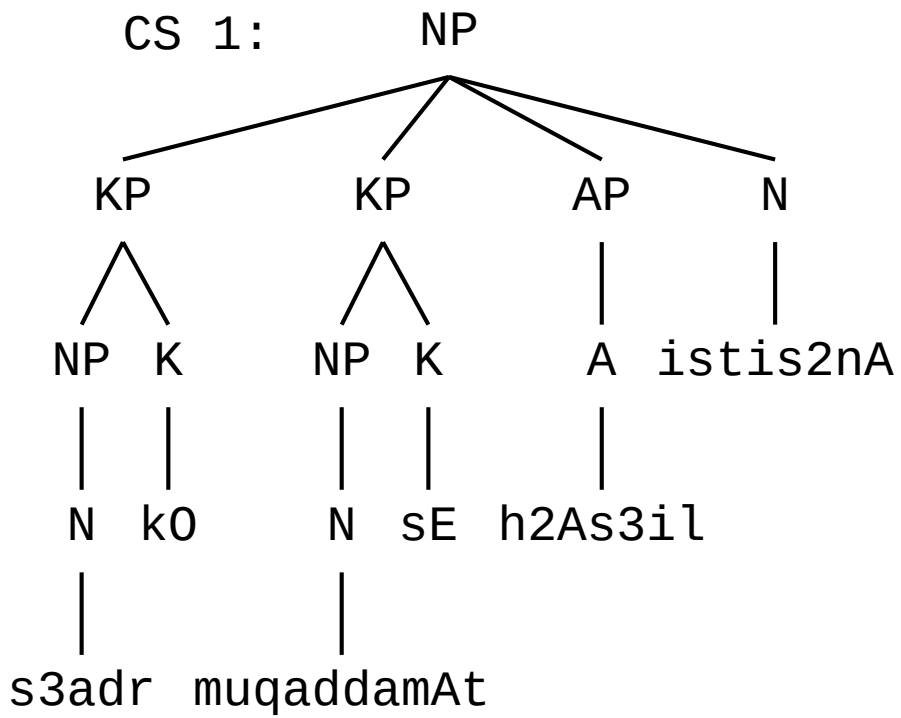
Excerpt from NP rule:

```
NP -> KP*:                                e.g.  sadr =ko
      (^ ADJUNCT $ OBJ-GO)= !
      (^ ADJUNCT) >h (^ ADJUNCT $ OBJ-GO)
      ...
```

- KP is an argument of the adjective *haasil* (which in turn is an ADJUNCT)
- therefore, KP is projected to OBJ-GO function within ADJUNCT set
- head of OBJ-GO must precede head of ADJUNCT in c-structure
- or: *sadr ko* must precede *haasil*

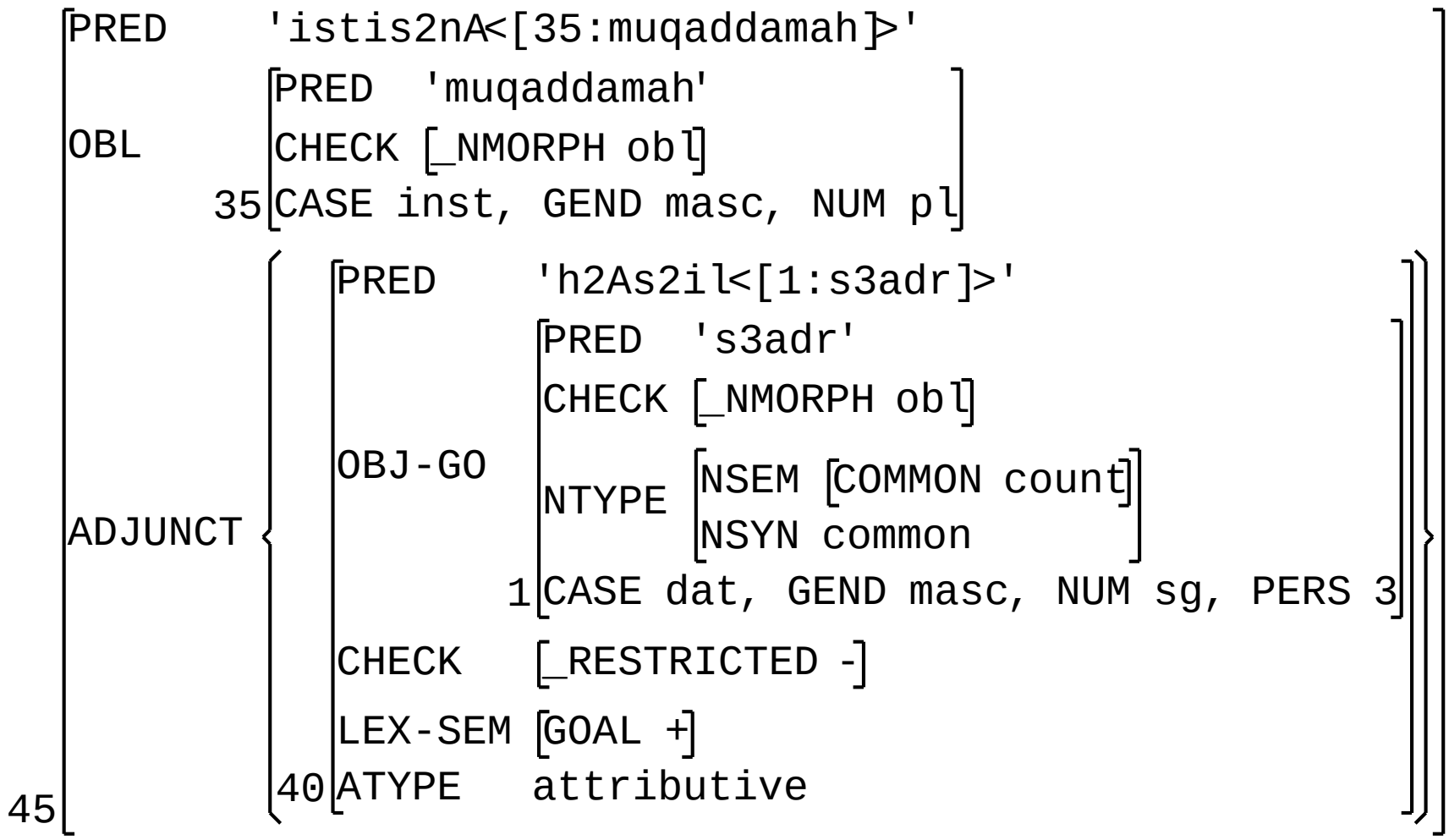
Sample Structures

sadr =ko muqaddamaat =se haasil istisnaa
president.M.Sg Dat court-cases.M.Pl Abl possessed immunity.M.Sg
'the immunity from court-cases possessed by the president'



Sample Structures

"s3adr kO muqaddamAt sE h2As3il istis2nA"



Sample Structures

Note that...

- using the shuffle operator, the NP rule has been designed to allow for varying word order
- using the head precedence operator, the head/argument requirement has been taken care of
- detailed functional annotation ensures that heads select for the correct arguments, based on case/postposition requirements