

Semantic Structure of the Indian Sign Language

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Overview

- **Indian Sign Language – An Introduction**
 - Sociolinguistic and Linguistic perspectives
 - Past Research in Sign Languages
 - Research in ISL
- **Surface Characterization of ISL**
 - Sentence level constructs
 - Inter-sentential constructs
- **A Schematization model for ISL**
 - The **COMPOSE** schema, Perceptual Schema ...

Introduction

Indian Sign Language

- Used by the deaf communities in the India
 - Dialectal variations observed
 - Not much known about geographical extent
- A much neglected “minority language”
 - Overwhelming oralist approach to deaf education
 - (Deshmukh '96)
 - Has seen very little research

Introduction

Indian Sign Language

- Visuo-spatial language
 - Extensive use of space
 - Iconic signs, Role play, Directional verbs, Non-manual markers, Person and Space deixis
- “Sentences” are predicate final
- Non manual markers
 - Facial Expression, Body Posture, Head orientation
 - Negation, Interrogatives, Causal Expressions, Conditionals

Introduction

Past Research in Sign Languages

- Theoretical
 - Structural/Descriptive
 - (Zeshan '02), (Sexton '99), (Stokoe '60)
 - Neuro-physiological
 - (Damasio '86), (Gordon '04)
- Computational
 - Representation Schemes
 - (Speers '02)
 - Translation Systems
 - (Kar *et al* '07), (Wray *et al* '04), (Zhao *et al* '00)

Introduction

Research in Indian Sign Language

- Structural/Descriptive
 - (Zeshan '00, '03, '04) - Description of surface forms
 - (Vasishta '86) - Sign language dictionaries
- Deaf Education
 - (Deshmukh '96) - Deaf education in India
- Computational
 - (Kar *et al* '07) - INGIT - MT from Hindi to ISL*
 - (Dasgupta *et al* '08) - Text to ISL MT

* **INGIT**: Limited Domain Formulaic Translation from Hindi to Indian Sign Language, In *Proceedings of ICON '07*.

Surface Characterization of ISL

Simple Predication

SIGN: TIME-YESTERDAY {^{top} 3PERS-IND-DEIX^{pos1}} ⟨D⟩ PLACE-IND-DEIX GO
TRAN: वह कल दिल्ली गया था

- Predicate final structure
- Absence of articles, copula
- Tense is a discourse level phenomenon
- Spatial deixis – markers of grammatical roles
 - Spatial Location
 - Body Orientation
- Mono-transitive events
 - Constituent ordering doesn't play a major role

SIGN: {^{nom} 3PERS-IND-DEIX^{pos1}} WALK INCEP
TRAN: उसने चलना शुरु किया

Surface Characterization of ISL

Simple Predication

- Di-transitive events
 - In case of asymmetric relation between similar participating entities – directional signs used
 - Constituent order flexible

SIGN: $\{^{nom} 1PERS-IND-DEIX \}$ BOOK READ COMPL
TRAN: मैने किताब पढ़ ली है

SIGN: $\{^{top} RAM 3PERS-IND-DEIX^{pos1} \}^{pos1} TEACH_{pos-1pers}$
TRAN: राम मुझे पढ़ाता है

- Trivalent events
 - Similar structure – directional verbs used to indicate grammatical roles

Surface Characterization of ISL

Simple Predication

- Constituent orderings

- Rarely involved in marking grammatical relations

SIGN: $\{^{nom} \text{RAM}\} \{^{nom} \text{SITA}\} \text{HEAR}$
TRAN: राम ने सीता को सुना

- Mostly the “relation” between the constituents is specified last
- If entities E_1, E_2, \dots, E_n are related as $\mathcal{R}(E_1, E_2, \dots, E_n)$ then the signing is $\langle E_1, E_2, \dots, E_n, \mathcal{R}(E_1, E_2, \dots, E_n) \rangle$
- However relaxation in ordering if constituent is a fully specified relation

SIGN: $\{^{nom} \text{1PERS-IND-DEIX}\} \text{THINK} \{^{nom} \text{3PERS-IND-DEIX}^{pos1}\} \text{TEACHER}$
SIGN: $\{^{nom} \text{3PERS-IND-DEIX}^{pos1}\} \text{TEACHER} \{^{nom} \text{1PERS-IND-DEIX}\} \text{THINK}$
TRAN: मुझे लगता है कि वह अध्यापक है

Surface Characterization of ISL

Sentence level constructs

- Negative Assertions

- Associated with a manual sign for negation
- Parallel non manual component

SIGN: $\{^{top} \text{1PERS-IND-DEIX} \} \text{SCHOOL} \{^{neg} \text{GO NEG} \}$
TRAN: मै स्कूल नहीं जा रहा

- Affirmative Interrogative

- Non redundant role played by non manual markers
- Manual signing identical to corresponding affirmative

SIGN: $\{^{yninter} \{^{top} \text{FEM 3PERS-IND-DEIX}^{pos1} \} \{^{hold} \text{TEACHER} \} \}$
TRAN: क्या वह औरत अध्यापक है?

Surface Characterization of ISL

Sentence level constructs

- Sentential Embeddings

- Two signing patterns observed

SIGN: $\{^{nom} 1PERS-IND-DEIX\}$ THINK $\{^{cinter} Q\}$ $\{^{nom} 3PERS-IND-DEIX^{pos1}\}$ TEACHER

SIGN: $\{^{nom} 3PERS-IND-DEIX^{pos1}\}$ TEACHER $\{^{nom} 1PERS-IND-DEIX\}$ THINK

TRAN: मुझे लगता है कि वह अध्यापक है

- Content Interrogatives

- Both manual as well as non-manual component
- Composed signs for temporal, location, person queries

SIGN: $\{^{cinter} SHOP OPEN TIME-Q\}$

TRAN: दुकान कब खुलती है?

Surface Characterization of ISL

Inter-sentential constructs

- Conditional Statements

- Exhibit embeddings in ISL
- The premise is terminated with a non manual marker
- A variant observed involves use of a finger-spelled IF

SIGN: $\{^{incomp}$ TIME-TODAY HOLIDAY $\{^{neg}$ NEG $\}$ $\}$ $\{^{top}$ SHOP $\}$ OPEN
TRAN: यदि आज छुट्टी नहीं है तो दुकान खुली होगी

- Conjunctions -Disjunctions

- “ISL has no ... conjunctions” (Zeshan '03)
- However finger-spelled AND is encountered
- More investigation required

Surface Characterization of ISL

Inter-sentential constructs

- Causal Expressions

- Realized in a dialogic form as a question answer tuple

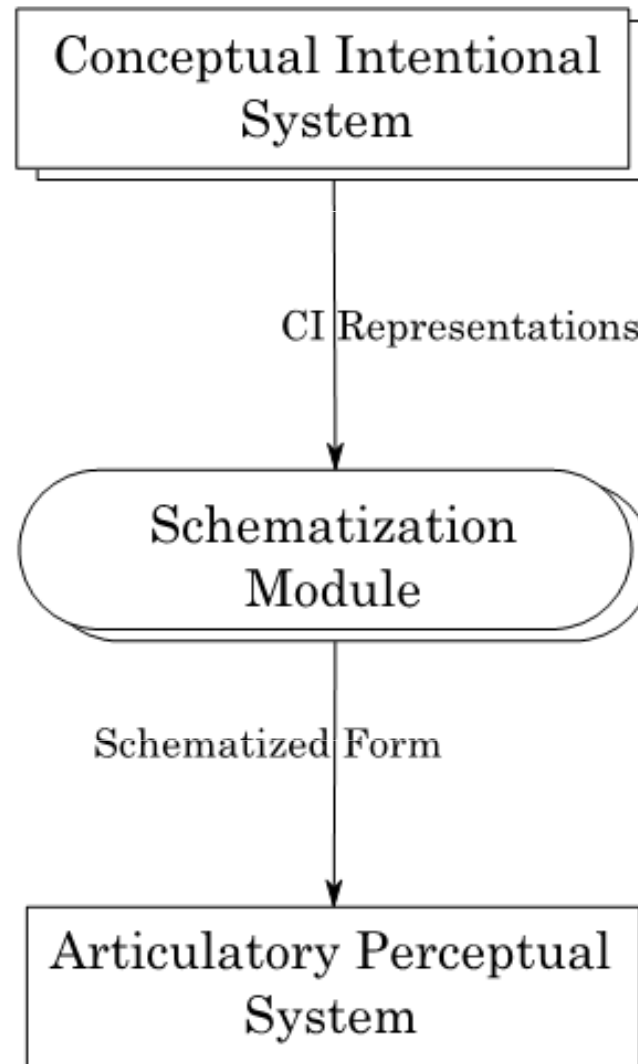
SIGN: $\{^{top} 1PERS-IND-DEIX SON \}$ SCHOOL $\{^{neg} GO NEG \}$ $\{^{cinter} Q \}$ SICK 3PERS-IND-DEIX
TRAN: मेरा बेटा स्कूल नहीं जा रहा क्योंकि वह बिमार है

- Relational Embeddings

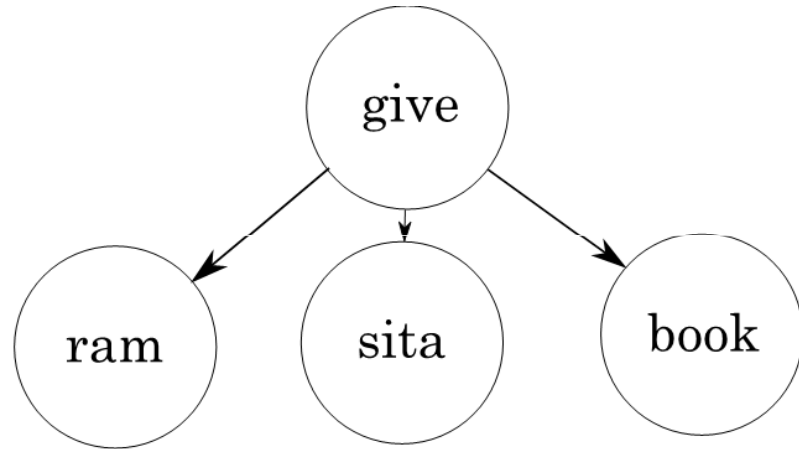
- Embedded clause signed after a non manual marker
- Example of surface embeddings in ISL
- More detailed investigation required

SIGN: $\{^{top} BOOK 3PERS-IND-DEIX^{pos1} \}$...
... $\{^{top} TIME-YESTERDAY 1PERS-IND-DEIX^{pos-1pers} GIVE_{pos-2pers} \}$...
... $\{^{top} 3PERS-IND-DEIX^{pos1} \}$ 1PERS-IND-DEIX
TRAN: मैंने जो किताब तुम्हे कल दी थी वह मेरी है

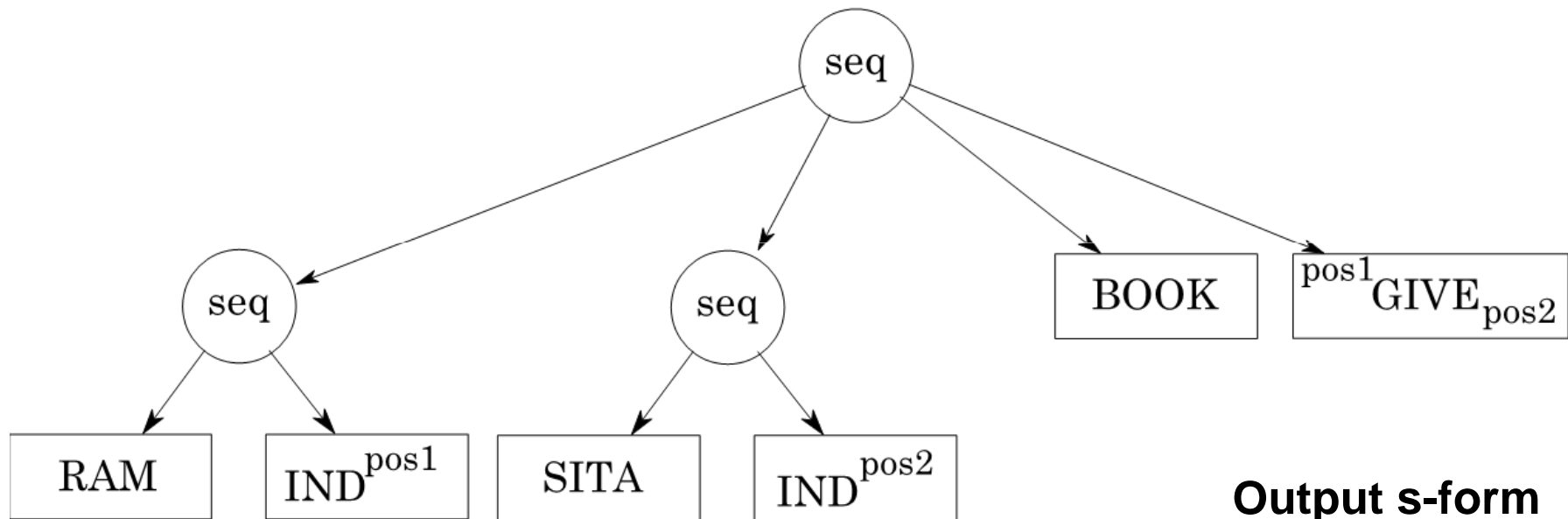
Semantic Schematization in ISL



Semantic Schematization in ISL



Input CIR



Output s-form

A Schematization Model

The Interface

- Autonomous, amodal, CI System
- CI Representations (**CIR**) – “Semantic parses”
- Schematized forms (**s-forms**)
 - weakly structured trees
 - Leaves contain individual signs
 - Leaves have a template

$$\left[\begin{array}{l} \text{MANUAL} = * \\ \text{FACIAL} = * \\ \text{BODY-POSTURE} = * \\ \text{BODY-ORIENTATION} = * \end{array} \right]$$

- Non-leaves contain temporal sequencing information

A Schematization Model

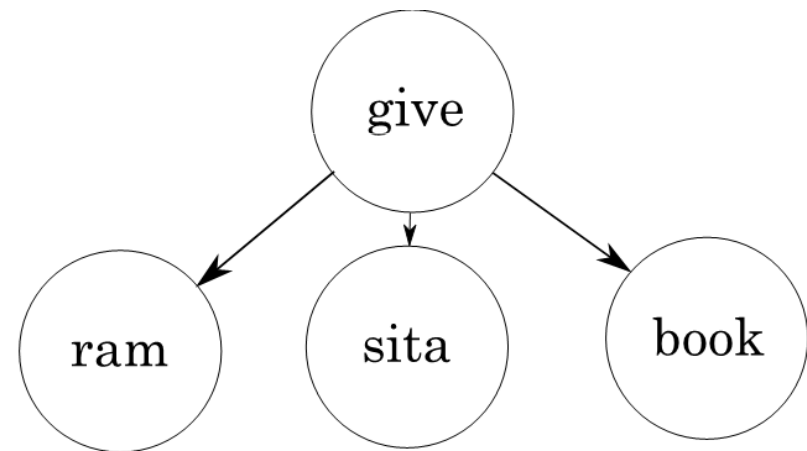
The Global store

- A mutable store being modified constantly
- Stores discourse level information
 - Tense Information
 - Spatial deixis type used – one of the following
 - Spatial Location (**SL**)
 - Body Orientation (**BO**)
 - Mappings of type
 - Spatial Location → Participating entity
 - Body Orientation → Pairs of participating entities

A Schematization Model

The COMPOSE schema

- Takes as input – a CIR and a template
- Schematizes the CIR according to the template and outputs an s-form that adheres to the template
- COMPOSE(book) is simply an articulation of the sign
- COMPOSE(give(ram,sita,book)) is handled by a schema for the concept GIVE
- Schema can recursively call COMPOSE for arguments



A Schematization Model

The Sentence schema

- Negation

- CIR is of form $C = \text{neg}(E)$: negation of the event E

- Template

$$\left\langle C, O, seq \left[\begin{array}{l} \text{MANUAL} = * \\ \text{FACIAL} = f \\ \text{BODY-POSTURE} = bp \\ \text{BODY-ORIENTATION} = bo \end{array} \right] \right\rangle$$

- Simply call COMPOSE with the arguments

$$\left\langle T, O, seq \left(\left[\begin{array}{l} \text{MANUAL} = * \\ \text{FACIAL} = f \\ \text{BODY-POSTURE} = bp \\ \text{BODY-ORIENTATION} = bo \end{array} \right], \left[\begin{array}{l} \text{MANUAL} = * \\ \text{FACIAL} = f + \text{negexp} \\ \text{BODY-POSTURE} = bp + \text{leanback} \\ \text{BODY-ORIENTATION} = bo \end{array} \right] \right) \right\rangle$$

A Schematization Model

The Event Schema

- SEE

- Has a **Perceptual Articulatory Schema (PAS)**
- The CIR see(*ram*, *sita*) would be “composed” as

$seq(\text{COMPOSE}(\textit{ram}), \text{COMPOSE}(\textit{sita}), PA_{\textit{see}}(\textit{loc}_{\textit{ram}}, \textit{loc}_{\textit{sita}}))$

- GIVE

- The PAS for GIVE
 - is similar to that of SEE: both involve directed movement
 - Is dissimilar from SEE: different hand shapes

- THINK

- Non- directional verb
- PAS simply consists of the hand shape, orientation and place of articulation

An Example

*Sentence corresponding to a CIR
s-form output*

[global store]

Initial Global Store

[Φ]

Yesterday, Ram met Sita

seq(COMPOSE(yesterday), COMPOSE(ram), COMPOSE(sita), COMPOSE(meet))

[past,SL,{ram→loc1,sita→loc2}]

He gave her a book

seq(COMPOSE(book),PA_give(loc1,loc2))

[past,SL,{ram→loc1,sita→loc2}]

He thought that she should go to school

seq(IND(loc1),COMPOSE(think),COMPOSE(Q),seq(IND(loc2),COMPOSE(school),
COMPOSE(go),COMPOSE(imperative)))

[past,SL,{ram→loc1,sita→loc2}]

Radha, who is Sita's sister, goes to school

seq(COMPOSE(radha),POSS(loc2),COMPOSE(sister),HOLD,seq(IND(loc3),
COMPOSE(school),COMPOSE(go)))

[null,SL,{ram→loc1,sita→loc2,radha→loc3}]

Future Work

- A broader surface characterization based on a larger corpus of data
 - adverbials, adjectives, adjuncts
 - conjunctions, disjunctions
- May lead to a refined schematization model
- Explore the COMPOSE schema in detail
 - Possibility of arriving at a unified schematization model for spoken and sign languages

For questions or suggestions, please contact Purushottam Kar at purushot@cse.iitk.ac.in or Achla M. Raina at achla@iitk.ac.in