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 manuals 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

Surface Characterization of ISL

Simple Predication

SIGN: \( \text{TIME-YESTERDAY} \{^\top 3\text{PERS-IND-DEIX}^{pos1} \} \langle D \rangle \text{PLACE-IND-DEIX GO} \)

TRAN: \( \text{वह कल दिखी गया था} \)

- 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: \( \{^\text{nom} 3\text{PERS-IND-DEIX}^{pos1} \} \text{WALK INCEP} \)

TRAN: \( \text{उसने चलना शुरू किया} \)
Surface Characterization of ISL

Simple Predication

• Di-transitive events
  – In case of asymmetric relation between similar participating entities – directional signs used
  – Constituent order flexible
    
    \[
    \begin{align*}
    \text{SIGN: } & \{^{\text{nom}} 1\text{PERS-IND-DEIX }\} \quad \text{BOOK READ COMPL} \\
    \text{TRAN: } & \quad \text{मैंने किताब पढ़ ली है}
    \end{align*}
    \]

    \[
    \begin{align*}
    \text{SIGN: } & \{^{\text{top}} \text{RAM } 3\text{PERS-IND-DEIX}^{\text{pos1}} \} \quad \text{pos1TEACH}_{\text{pos-1pers}} \\
    \text{TRAN: } & \quad \text{राम मुझे पढ़ाता है}
    \end{align*}
    \]

• 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
    \[ \text{SIGN: } \{\text{nom} \text{ RAM} \} \{\text{nom} \text{ SITA} \} \text{HEAR} \]
    \[ \text{TRAN: } \text{राम ने सीता को सुना} \]
  - Mostly the “relation” between the constituents is specified last
  - If entities \( E_1, E_2, \ldots, E_n \) are related as \( \mathcal{R}(E_1, E_2, \ldots, E_n) \) then the signing is \( \langle E_1, E_2, \ldots, E_n, \mathcal{R}(E_1, E_2, \ldots, E_n) \rangle \)
  - However relaxation in ordering if constituent is a fully specified relation
    \[ \text{SIGN: } \{\text{nom} \text{ 1PERS-IND-DEIX} \} \text{THINK} \{\text{nom} \text{ 3PERS-IND-DEIX}^{pos1} \} \text{TEACHER} \]
    \[ \text{SIGN: } \{\text{nom} \text{ 3PERS-IND-DEIX}^{pos1} \} \text{TEACHER} \{\text{nom} \text{ 1PERS-IND-DEIX} \} \text{THINK} \]
    \[ \text{TRAN: } \text{मुझे लगता है कि वह अध्यापक है} \]
Sentence level constructs

• Negative Assertions
  • Associated with a manual sign for negation
  • Parallel non manual component

\[
\begin{align*}
\text{SIGN: } & \{^{top} 1\text{PERS-IND-DEIX } \} \text{ SCHOOL } \{^{neg} \text{ GO NEG } \} \\
\text{TRAN: } & \text{मैं स्कूल नहीं जा रहा}
\end{align*}
\]

• Affirmative Interrogative
  • Non redundant role played by non manual markers
  • Manual signing identical to corresponding affirmative

\[
\begin{align*}
\text{SIGN: } & \{^{yninter} \{^{top} \text{FEM 3PERS-IND-DEIX}^{pos1} \} \} \{^{hold} \text{TEACHER} \} \} \\
\text{TRAN: } & \text{क्या वह औरत अध्यापक है?}
\end{align*}
\]
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: {\textit{incomp} TIME-TODAY HOLIDAY \{\textit{neg} NEG \} \{\textit{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
  
  \[
  \text{SIGN: } \{^{top} 1\text{PERS-IND-DEIX SON } \} \text{ SCHOOL } \{^{neg} \text{GO NEG } \} \{^{inter} \text{Q } \} \text{ SICK } 3\text{PERS-IND-DEIX}
  \]
  
  \[
  \text{TRAN: } \text{मेरा बेटा स्कूल नहीं जा रहा क्योंकि वह बिल्ली है}
  \]

- Relational Embeddings
  - Embedded clause signed after a non manual marker
  - Example of surface embeddings in ISL
  - More detailed investigation required
  
  \[
  \text{SIGN: } \{^{top} \text{BOOK } 3\text{PERS-IND-DEIX}{^{pos1}} \} \ldots
  \]
  
  \[
  \ldots \{^{top} \text{TIME-YESTERDAY } 1\text{PERS-IND-DEIX } {^{pos-1}}\text{PERS GIVE}{^{pos-2}}\text{PERS} \} \ldots
  \]
  
  \[
  \ldots \{^{top} 3\text{PERS-IND-DEIX}{^{pos1}} \} 1\text{PERS-IND-DEIX}
  \]
  
  \[
  \text{TRAN: } \text{मैंने जो किताब तुम्हें कल दी थी वह मेरी है}
  \]
Semantic Schematization in ISL

Conceptual Intentional System

CI Representations

Schematization Module

Schematized Form

Articulatory Perceptual System

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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
    \[
    \begin{bmatrix}
    \text{MANUAL} = *
    \\
    \text{FACIAL} = *
    \\
    \text{BODY-POSTURE} = *
    \\
    \text{BODY-ORIENTATION} = *
    \end{bmatrix}
    \]
  – 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 $\rightarrow$ Participating entity
    • Body Orientation $\rightarrow$ 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 = neg(E): negation of the event E
  - Template
    \[
    \left( C, O, seq \begin{array}{c}
    MANUAL = * \\
    FACIAL = f \\
    BODY-POSTURE = bp \\
    BODY-ORIENTATION = bo \\
    \end{array} \right)
    \]
  - Simply call COMPOSE with the arguments
    \[
    \left( T, O, seq \begin{array}{c}
    MANUAL = * \\
    FACIAL = f \\
    BODY-POSTURE = bp \\
    BODY-ORIENTATION = bo \\
    \end{array} \right), \left( REL \begin{array}{c}
    MANUAL = * \\
    FACIAL = f + negexp \\
    BODY-POSTURE = bp + leanback \\
    BODY-ORIENTATION = bo \\
    \end{array} \right)
    \]
A Schematization Model

The Event Schema

- **SEE**
  - Has a **Perceptual Articulatory Schema (PAS)**
  - The CIR see(ram, sita) would be “composed” as
    \[
    \text{seq}(\text{COMPOSE}(\text{ram}), \text{COMPOSE}(\text{sita}), P_{A_{\text{see}}}(\text{loc}_{\text{ram}}, \text{loc}_{\text{sita}}))
    \]

- **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

<table>
<thead>
<tr>
<th>Sentence corresponding to a CIR s-form output</th>
</tr>
</thead>
</table>

#### Initial Global Store

<table>
<thead>
<tr>
<th>[global store]</th>
</tr>
</thead>
</table>

#### Example

*Yesterday, Ram met Sita*

\[ \text{seq}(\text{COMPOSE}(\text{yesterday}), \text{COMPOSE}(\text{ram}), \text{COMPOSE}(\text{sita}), \text{COMPOSE}(\text{meet})) \]

*He gave her a book*

\[ \text{seq}(\text{COMPOSE}(\text{book}), \text{PA}_\text{give}(\text{loc1}, \text{loc2})) \]

*He thought that she should go to school*

\[ \text{seq}(\text{IND}(\text{loc1}), \text{COMPOSE}(\text{think}), \text{COMPOSE}(\text{Q}), \text{seq}(\text{IND}(\text{loc2}), \text{COMPOSE}(\text{school}), \text{COMPOSE}(\text{go}), \text{COMPOSE}(\text{imperative}))) \]

*Radha, who is Sita’s sister, goes to school*

\[ \text{seq}(\text{COMPOSE}(\text{radha}), \text{POSS}(\text{loc2}), \text{COMPOSE}(\text{sister}), \text{HOLD}, \text{seq}(\text{IND}(\text{loc3}), \text{COMPOSE}(\text{school}), \text{COMPOSE}(\text{go}))) \]

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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