

Automatic Interpretation of Dialogue Acts

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Last Time

DAMSL (Dialogue Act Markup in Several Layers)
(Allen&Core'1997; Walker et al'1996; Carletta'1997)

- Driven by the needs of dialog system developers
- Contains several levels, including **forward looking function** and **backward Looking function**
- Hierarchical in structure
- Domain-independent, but tailored towards task-oriented dialogs

DAMSL

- STATEMENT: a claim made by a speaker
- INFO-REQUEST: a question by the speaker
- CHECK: question for confirming information
- ACCEPT: a claim made by a speaker
- ANSWER: answering a question
- UNDERSTANDING: whether speaker understands

Today

Automatic Interpretation of Dialogue Acts

- Plan-Inferential Interpretation
- Cue-based Interpretation

Example

YES-NO-QUESTION: Will breakfast be served on USAir 1557?

STATEMENT: I don't care about lunch

COMMAND: Show me flights from Milwaukee to Orlando on Thursday night

Interpretation is Easy!

YES-NO-QUESTIONS have aux-inversion

STATEMENTS have declarative syntax (no aux-inversion)

COMMANDS have imperative syntax (commands with no syntactic subject)

Interpretation is NOT Easy!

The mapping between surface form and speech act is not obvious and not one-to-one

QUESTION vs REQUEST: Can you give me a list of flights from Atlanta to Boston?

QUESTION vs STATEMENT:... And you said you want to travel next week?

Two Solutions

- Shallow Processing: act classification based on lexical, prosodic and structural cues
- Deep Understanding: inference-based interpretation

Plan-Inferential Interpretation

(Gordon&Lakoff, 1971; Searle, 1975): A speaker could mention or question various properties of the desired activity to make an indirect request

- The speaker can mention the hearer's ability to perform the action

Can you give me the list of the flights from Atlanta to Boston?

Would you be able to put me on the flight with Delta?

- The speaker can mention speaker's wish or desire about the activity

I want to fly from Boston to San Francisco

I would like to stop somewhere else in between

Plan-Inferential Interpretation

- The speaker can mention the hearer's doing the action

Would you please repeat this information?

Will you tell me the departure time on American flight?

- The speaker can question the speaker's having permission to receive results of the action

May I get lunch instead of breakfast?

Could I have a listing of flights leaving Boston?

Searle's Inference Chain

1. X asked me a question about whether I have the ability to give a list of flights
2. I assume that X is being cooperative in the conversation and that his utterance therefore has some plan
3. X knows that I have the ability to give such a list , and therefore is no alternative reason why X should have purely theoretical interest in my list-giving ability
4. Therefore X's utterance has some illocutionary point. What can it be?

Searle's Inference Chain

5. A preparatory condition for a directive is that the hearer have the ability to perform the directed action
6. Therefore X has asked me a question about my preparedness for the action of giving X a list of flights
7. Furthermore, X and I are in a conversational situation in which giving flights is expected and common activity

8. Therefore, in the absence of any other plausible act, X is probably requesting me to give him a list of flights

BDI Models

Belief, Desire and Intention Models (Cohen & Perrault, 1979; Perrault & Allen, 1980; Allen, 1995)

- Used for generation and understanding
- Based on formalization of Searle's Inference Chains via planning techniques

BDI Basics

- *Belief:*

$B(S, P)$

$$B(A, P) \wedge B(A, Q) \rightarrow B(A, P \wedge Q)$$

- *Know*

$$KNOW(S, P) \equiv P \wedge B(S, P)$$

- *Know Whether*

$$KNOWIF(S, P) \equiv$$

$$KNOW(S, P) \vee KNOW(S, \neg P)$$

- *Want*

$$W(S, P), W(S, S(ACT(H)))$$

BDI Axiomatization

Action Schemas (similar to STRIPS)

- **Constraints:** Variable types
- **Preconditions:** Conditions that must already be true to successfully perform the action
- **Effects:** A set of partially ordered goal states that must be achieved in performing the actions
- **Body:** A set of partially ordered goal states that must be achieved in performing the action

Example of Action Schema

BOOK-FLIGHT (A,C,F)

Constraints: $\text{Agent}(A) \wedge \text{Flight}(F) \wedge \text{Client}(C)$

Precondition: $\text{Know}(A, \text{departure-date}(F)) \wedge \text{Know}(A, \text{departure-time}(F)) \wedge \text{Know}(A, \text{origin-city}(F)) \wedge \text{Know}(A, \text{destination-city}(F)) \wedge \text{Has-Seats}(F) \wedge \dots$

Effect: $\text{Flight-Booked}(A, C, F)$

Body: $\text{Make-Reservation}(A, F, C)$

INFORM Definition

Grice: A speaker informs the hearer of something merely by causing the hearer to believe that the speaker wants them to know something

INFORM (S,H,P)

Constraints: Speaker (S) \wedge Hearer (H) \wedge Proposition (P)

Precondition: Know (S,P) \wedge W(S, INFORM (S, H, P))

Effect: Know (H, P)

Body: B (H, W (S, Know (H, P)))

REQUEST Definition

REQUEST (S,H,ACT)

Constraints: Speaker (S) \wedge Hearer (H) \wedge ACT (A)

Preconditions: W(S, ACT(H))

Effect: W (H, ACT (H))

Body: B (H, W (S, ACT (H)))

Surface Acts

- “Surface-level acts” correspond to the literal meaning of the imperative, interrogative and declarative structures:
S.REQUEST (S,H,ACT)
 - B (H, W(S, ACT(H)))
- They trigger the start of the hearer’s inference chain (by matching the body of a request)

Speaker: S. REQUEST (S, H, InformIf (H, S, CanDo(H,Give (H, S, LIST))))

Hearer: REQUEST (H, S, GIVE,(H, S, LIST))

Plan Inference Rules (PI)

- **(PI. AE) Action-Effect Rule:** For all agents S and H, if Y is an effect of action X and if H believes that S wants X to be done, then it is plausible that H believes that S wants Y to obtain
- **(PI. PA) Precondition-Action Rule:** For all agents S and H, if X is a precondition of actions Y and if H believes S wants X to obtain, then it is plausible that H believes that S wants Y to be done
- **(PI. BA) Body-Action Rule:** For all agents S and H, if X is part of the body of Y and if H believes that S wants X done, then it is plausible that H believes that S wants Y done

Plan Inference Rules (PI)

- **(PI. KP) Know-Desire Rule:** For all agents S and H, if H believes S wants to KNOWIF(P), then H believes S wants P to be true:

$$B(H, W(S, KNOWIF(S, P))) \implies^{plausible} B(H, W(S, P))$$

- **(EI. 1) Extended Inference Rule:** $B(H, W(S))$ can be added to any plan inference rules:

If $B(H, W(S, X)) \implies^{plausible} B(H, W(S, Y))$ is a PI rule, then

$$B(H, W(S, B(H, (W(S, X)))))) \implies^{plausible} B(H, W(S, B(H, (W(S, Y))))))$$

Example of Inference

Can you give me a list of flights from Atlanta?

1. **S.REQUESTS**

(S,H,InformIf(H,S,CanDo(H,Give(H,S,LIST))))

2. **PI.AE:**

B(H,W(S,InformIf(H,S,CanDo(H,Give(H,S,LIST))))))

3. **PI.AE/EI:**

B(H,W(S,KnowIF(H,S,CanDo(H,Give(H,S,LIST))))))

4. **PI.KP/EI:** B(H,W(S,CanDo(H,Give(H,S,LIST))))

5. **PI.KP/EI:** B(H,W(S, Give(H,S,LIST)))

6. **PI.BA:** REQUEST(H,S,GIVE(H,S,LIST))

Pros/Cons of Inference Approaches

Cue-based Interpretation

Microgrammar of dialogue (Goodwin, 1996)

1. Words and Collocations (*please* for **REQUEST**)
2. Prosody (rising pitch for **YES-NO-QUESTIONS**)
3. Conversational Structure (*yeah* after **PROPOSAL** likely to be an agreement; after **AGREEMENT** likely to be a backchannel)

Dialogue MicroGrammar

(Sumh&Weibel, 1994; Mast et al, 1996; Stolcke et al, 2001)

$$d^* = \operatorname{argmax}_d P(d|W) = \operatorname{argmax}_d P(d)P(W|d)$$

Example: Ngrams with high predictive power for reformulation:

so you, you mean, so they, so it's

Incorporating Dialogue Structure

E - observable evidence consisting of prosodic features (F) and lexical features (W)

$$D = \{d_1, d_2, \dots, d_N\}$$

$$D^* = \operatorname{argmax}_D P(d|E) = \operatorname{argmax}_D \frac{P(D)P(E|D)}{P(E)} = \operatorname{argmax}_D P(D)P(E|D)$$

$$P(E|D) = P(F|D)P(W|D) = \operatorname{argmax}_D P(D)P(F|D)P(W|D)$$