Information State Update (ISU)

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Outline

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- Information State-based Approach

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Dialogue Management System (Intro)

Almost all the decision makers today often race against time and often say: "I am too busy today to learn". This statement comes even after they have been provided with the latest sophisticated equipment and office automation systems.

One of the main reason that can be thought of is the absence of a good dialogue management subsystem. A dialogue management subsystem acts as a window to the DSS and provides a good user interface.

Dialogue Management

Role: Controls the dialogue flow, namely:

- Updating the dialogue context on the basis of interpreted communication.

- Providing context-dependent expectations for interpretations of observed signals as communicative behaviour.

- Interfacing with task/domain processing (e.g. Database, planner, execution module, other back-end system) to coordinate dialogue and non-dialogue behaviour and reasoning.

- Deciding what content to express next and when to express it.

Type of Dialogue Systems / Dialogue Management

- According to the input type:
  - Only Spoken(especially important for disable user)
  - Only text (quite rare)
  - Spoken + DTMF (Dual Tone Multiple Frequency)(very frequent)
- According to the output type:
  - Spoken
  - Text
  - Text with visual elements(graphics, images, tables)
- According to the initiator of dialogue:
  - System-directed
  - User-directed
  - Mixed-initiative

Information State-Based Approach

- Model for best practice in the development of the dialogue management component of a spoken dialogue system.(Staffan Larson and David Traum) [1]

- It is a view of dialogue management functions in terms of information state.

- Also referred to "Conversational Score" or "Discourse Context" or "Mental State" names.

Key in ISU

- Identifying the relevant aspects of information in dialogue how they are updated, and how updating processes are controlled.

  Or

- Is the notion of UPDATE of information state, with most updates related to the observation and performance of DIALOGUE MOVES.

Information State theory

- Represents the information necessary to distinguish it from other dialogues, representing the cumulative additions from previous actions in the dialogue, and motivating future actions.

Information State Theory (cont)

- Informational Components
- Formal Representations
- Dialogue Moves
- Update Rules
- Update Strategy
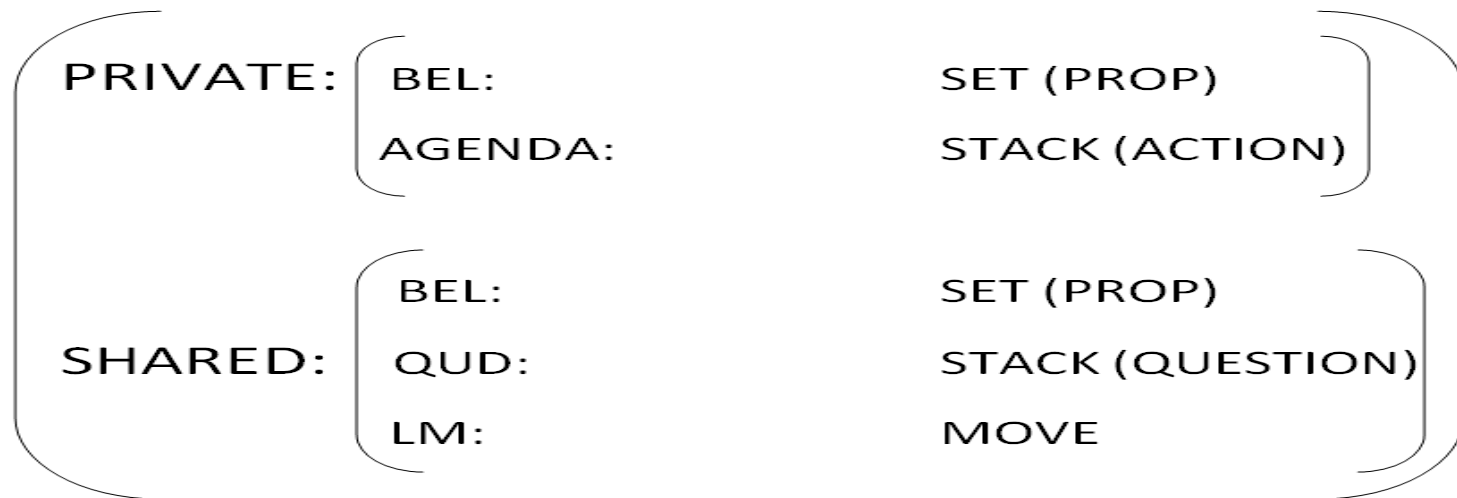
Informational Components

- Including aspects of common context as well as internal motivating factors (e.g. participants, common ground, linguistic and intentional structure, obligations and commitments, beliefs, intentions, user model, etc)

- There is some information assumed to be private:
  - Beliefs (BEL)
  - Agenda of actions to perform in the dialogue (AGENDA)

- There is some information assumed to be shared:
  - Propositions assumed to be shared beliefs (BEL)
  - Questions Under Discussion (QUD)
  - The Latest dialogue Move performed (LM)

Information State Theory (cont)

- ~~Informational Components~~

- Formal Representations

- Dialogue Moves

- Update Rules

- Update Strategy

Formal Representation

- Lists
- Sets
- Typed feature structures
- Records
- Discourse Representation Structures (DRS's)
- Propositions or modal operators within a logic

PRIVATE: [BEL: SET (PROP)

           AGENDA: STACK (ACTION)]

SHARED: [BEL: SET (PROP)

           QUD: STACK (QUESTION)

           LM: MOVE]

Information state represented as a record (Cooper & Larson)

Information State Theory (cont)

- ~~Informational Components~~

- ~~Formal Representations~~

- Dialogue Moves

- Update Rules

- Update Strategy

Dialogue Moves

- An abstraction between the large number of different possible messages that can be sent and the types of update to be made on the basis of performed utterances.

- Trigger the update of the information state.

- Provide abstract level for content generation.

Information State Theory (cont)

- ~~Informational Components~~

- ~~Formal Representations~~

- ~~Dialogue Moves~~

- Update Rules

- Update Strategy

Update Rules

- Governing the update of information state as the dialogue progresses.

- Update rules are meant to encapsulate coherent bundles of change to the IS via given particular theory of dialogue.

Information State Theory (cont)

- ~~Informational Components~~
- ~~Formal Representations~~
- ~~Dialogue Moves~~
- ~~Update Rules~~
- Update Strategy

Update Strategy

- Take the first rule that applies (iteratively until no rules apply)

- Apply each rule (if applicable) in sequence

- Apply rules according to class

- Choose among applicable rules using probabilistic information

- Present choices to user to decide (for development modes)

Sample ISU

$$(2) \quad \text{U-RULE: } \textbf{integrateSysAsk}$$

$$\text{PRE: } \begin{cases} \text{val}(\text{SHARED.LM, ask}(\text{usr}, Q)) \\ \text{fst}(\text{PRIVATE.AGENDA, raise}(Q)) \end{cases}$$

$$\text{EFF: } \begin{cases} \text{push}(\text{SHARED.QUD, } Q) \\ \text{pop}(\text{PRIVATE.AGENDA}) \end{cases}$$

$$(3) \quad \text{U-RULE: } \textbf{selectAsk}$$

$$\text{PRE: } \{ \quad \text{fst}(\text{PRIVATE.AGENDA, raise}(Q))$$

$$\text{EFF: } \{ \quad \text{set}(\text{NEXT\_MOVE, ask}(Q))$$

Sample ISU

$$
(4) \quad \text{U-RULE:} \ \textbf{integrateUserAnswer}
$$

$$
\text{PRE:} \begin{cases}
\text{val}(\text{SHARED.LM, answer}(\text{usr},A)), \\
\text{fst}(\text{SHARED.QUD}, Q) \\
\text{DOMAIN} :: \text{relevant}(\ A, Q\ ) \\
\text{DOMAIN} :: \text{reduce}(\ Q, A, P\ )
\end{cases}
$$

$$
\text{EFF:} \big\{ \ \text{add}(\text{SHARED.BEL}, P)
$$

$$
(5) \quad \text{U-RULE:} \ \textbf{downdateQUD}
$$

$$
\text{PRE:} \begin{cases}
\text{fst}(\text{SHARED.QUD}, Q) \\
\text{in}(\text{SHARED.BEL}, P) \\
\text{DOMAIN} :: \text{resolves}(P, Q)
\end{cases}
$$

$$
\text{EFF:} \big\{ \ \text{pop}(\text{SHARED.QUD})
$$

Sample ISU – Question Answer Exchange

$$\left[\begin{array}{lll} \text{PRIVATE} & = & \left[\begin{array}{lll} \text{BEL} & = & \{\} \\ \text{AGENDA} & = & \langle\text{raise}(?x.\text{dest-city}(x)),\ \text{raise}(\ldots),\ \ldots\rangle \end{array}\right] \\ \text{SHARED} & = & \left[\begin{array}{lll} \text{BEL} & = & \{\} \\ \text{QUD} & = & \langle\rangle \\ \text{LM} & = & \ldots \end{array}\right] \end{array}\right]$$

U-RULE: **selectAsk**

EFF: $\{$ set(NEXT_MOVE, ask($?x$.dest-city(x)))

Sys: Where do you want to go?

U-RULE: **integrateSysAsk**

EFF: $\left\{\begin{array}{l} \text{push}(\text{SHARED.QUD},\ ?x.\text{dest-city}(x)) \\ \text{pop}(\text{PRIVATE.AGENDA}) \end{array}\right.$

$$\left[\begin{array}{lll} \text{PRIVATE} & = & \left[\begin{array}{lll} \text{BEL} & = & \{\} \\ \text{AGENDA} & = & \langle raise(?x.depart-city(x)),\ldots\rangle \end{array}\right] \\ \text{SHARED} & = & \left[\begin{array}{lll} \text{BEL} & = & \{\} \\ \text{QUD} & = & \langle\ ?x.\text{dest-city}(x)\rangle \\ \text{LM} & = & \text{ask}(?x.\text{dest-city}(x)) \end{array}\right] \end{array}\right]$$

Usr: Malvern

Sample ISU - Question Answer Exchange

U-RULE: **integrateUsrAnswer**

EFF: $\{$ add(SHARED.BEL, dest-city(malvern))

U-RULE: **downdateQUD**

EFF: $\{$ pop(SHARED.QUD)

$$
\begin{bmatrix}
\text{PRIVATE} & = & \begin{bmatrix} \text{BEL} & = & \{\} \\ \text{AGENDA} & = & \langle\, \text{raise}(?x.\text{depart-city}(x)),\, \ldots \rangle \end{bmatrix} \\
\text{SHARED} & = & \begin{bmatrix} \text{BEL} & = & \{\text{dest-city}(\text{malvern})\} \\ \text{QUD} & = & \langle\rangle \\ \text{LM} & = & \text{answer}(\text{malvern}) \end{bmatrix}
\end{bmatrix}
$$

Conclusion

- The complexity of dialogue manager depends on the complexity of the "Natural Language" to be used.

- Presented five components model of the formalization of dialogue theories as ISU.

- There is a synergy between choices of the components for ISU.

- A complete theory of dialogue update will need to include smoothly interacting combination of these aspects. (5 factors)

- Possibility to track information states in simple information-seeking dialogue.

- ISU is interesting and very flexible - supports a wide variety of dialog management approaches.

The End

Thank you for your attention.

Any question?

Literature:

- [1]. Staffan Larsson and R. Traum, David: Information state and dialogue management in the TRINDI dialogue, move engine toolkit, 2000, Department of Linguistics, Göteborg University, Sweden.

- [2]. David Traum and Staffan Larsson (2003): The Information State Approach to Dialogue Management. To appear in Smith and Kuppevelt (eds.): Current and New Directions in Discourse & Dialogue, Kluwer Academic Publishers. (pp. 325-353, 28 pages).

- [3]. Ginzburg, J.:Dynamics and the semantics of dialogue. In: Logic, language and computation, vol 1, 1996.