Language Technology II
Dialogue Management

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Outline

- Tasks of dialogue management
- Dialogue-flow control
- Finite State-Based DM
- Frame-Based DM
- ISU-Based DM
- Grounding and Verification
- Inititative and Cooperation
- Current challenges

Dialogue Modeling
as
Information State Update

Information State (IS)

- Representation of the current state of dialogue
- Used by system to
  - Interpret user's turn
  - Decide which external actions to take
  - Decide what to say
  - Store information (dialogue context representation)
- Utterances update information state
- Approaches to DM differ in how IS is represented, what role it plays, what it contains

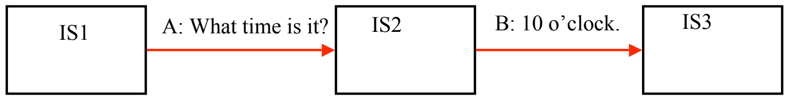
ISU-Based Theories

- Any theory following the ISU aproach should define:
  - A descripition of the informational components of the IS and their formal representation
  - A set of dialogue moves triggering the update of the IS
  - A set of update rules governing the IS updating
  - A control strategy to decide which update rule(s) to select at a given point in the dialogue

IS Update Rules

- Describe possible transitions from one information state to the next

  If <conditions-on-IS-values>
  then <changes-to-IS-values>



- When applicable
- What IS change

FS as ISU

- IS: current-state; input
- Update rules:
  - If [state] & [input]
    then [output]; [next-state]
- Example for elevator or account-balance

Frame-Based as ISU

- IS: task-frame; user's move; system move
- Update rules: e.g.,
  - If [user move = slot X value V] then [fill X with V]
  - If <conditions-on-frame-values>
    then <ask-slot-value Y>
- Decision about next system move is also a rule
- Example for travel dialogue

ISU-Based Dialogue Modeling

- Task- vs. Dialogue-Structure
  - Task --> dialogue
  - But, dialogue does not have to follow task (execution) structure
- "Dialogue planning" (agenda)
  - Task model fills agenda with task-related goals
  - Dialogue manager can add more goals, e.g., for grounding
- Some approaches:
  - QUD-based (Godis)
  - Obligation-based (Edis)
  - Agent-based: collaborative problem solving (TALK)

QUD-Based ISU Modeling

- Information state in Godis:

```
PRIVATE : [ AGENDA : stack( Action )
            PLAN : stack( Action )
            BEL : set( Prop ) ]
SHARED :  [ COMMITMENTS : set( Prop )
            QUD : stack( Question )
            LU: [ SPEAKER: Speaker
                  MOVES: assocSet( Move ) ] ]
```

+ module interface variables

INPUT : String
LATEST-MOVES: Set(Move)
LATEST-SPEAKER: Speaker
NEXT-MOVES: Set(Move)
OUTPUT: String

QUD-Based ISU Modeling

U: "how much does a flight cost?"
- if user asks Q, push respond(Q) on AGENDA
- if respond(Q) on AGENDA and PLAN empty, find plan for Q and load to PLAN
- if findout(Q) first on PLAN, ask Q

S: "where do you want to go?"

U: "Paris"
- if LM=answer(A) and A **about** Q, then add P=Q[A] to SHARED.COM
- if P in SHARED.COM and Q topmost on QUD and P **resolves** Q, then pop QUD
- if P in SHARED.COM and P **fulfils goal** of findout(Q) and findout(Q) on PLAN, then pop PLAN

QUD-Based ISU Modeling

- Sample dialogue plan:

  findout(?x.transport(x))
  findout(?x.dest-city(x))
  findout(?x.depart-city(x))
  findout(?x.dept-month(x))
  findout(?x.dept-day(x))
  findout({?class(economy), ?class(business)}
  consultDB(?x.price(x))
  respond(?x.price(x))

⇒ system's agenda

QUD-Based ISU Modeling

- IS update rule for answer integration: integrateAnswer

pre:
- in($SHARED.LU.MOVES, answer(A))
- fst($SHARED.QUD, Q)
- $DOMAIN:about(A, Q)

eff:
- DOMAIN: combine(Q, A, P)
- add(SHARED.COM, P)

- Before an answer can be integrated by the system, it must be matched to a question on QUD

QUD-Based ISU Modeling

…

S: ”what class did you have in mind?”

U: ”cheap”

- if consultDB(Q) on PLAN, consult database for answer to Q; store result in PRIVATE.BEL
- if Q on QUD and P in PRIVATE.BEL s.t. P resolves Q, answer(P)

S: ”The price is £123”

QUD-Based ISU Modeling

- Dealing with multiple issues:
  - if user asks Q, push Q on QUD and load plan for dealing with Q
  - if users asks Q’ while system is dealing with Q, **throw out plan for Q** but Q remains on QUD
  - when Q’ resolved, Q topmost on QUD will trigger reloading plan for dealing with Q
    - general rule: if SHARED.COM contains info resolving Q, don’t ask Q
    - so any resolved questions in plan will be thrown out

QUD-Based ISU Modeling

U: I want price information [raise ?x.price(x)]

S: Where do you want to go?

U: London

S: When do you want to travel?

QUD=<?x.dept-month(x), ?x.price(x)>

U: Do I need a Visa? [raise ?visa]

QUD=<?visa, ?x.dept-date(x), ?x.price(x)>

S: Where are you travelling from?

U: Gothenburg

S: No, you don’t need a Visa.

QUD=<?x.dept-month(x), ?x.price(x)>

PLAN empty;

QUD-Based ISU Modeling

(1)
U: OK.
  QUD=<?x.dept-month(x), ?x.price(x)>
  PLAN empty, so reload plan for dealing with ?x.price(x)
  Throw out all questions which have already been resolved; raise the first unresolved question on plan
S: When do you want to travel? [= question re-raising]
U: I want to leave in April
S: What day do you want to leave?

(2)
U: OK, I want to leave in April [answers dept-month(april)]
  QUD=<?x.price(x)>
  PLAN empty, so reload plan for dealing with ?x.price(x)
  Throw out all questions which have already been resolved; raise the first unresolved question on plan
S: What day do you want to leave?
...

ISU-Based DM

- A range of systems developed in various projects: Trindi, Siridus, D'Homme, BEETLE, WITAS, TALK, …
- Software tools:
  - TrindiKit (Gothenburg U.) http://www.ling.gu.se/trindi/trindikit/
  - Dipper (U. of Edinburgh) http://www.ltg.ed.ac.uk/dipper/
  - MIDIKI (MITRE Corp.) http://midiki.sourgeforge.net/
  - Rubin (CLT, Saarbruecken)

QUD-Based ISU Modeling

- Advantages:
  - Generic approach to dialogue modeling
  - Handling various dialogue phenomena
    - Accommodation ("overanswering")
    - Reraising of issues
    - Task switching, sharing information across tasks
    - Various dialogue genres (e.g., negotiation, tutoring…)
    - …
- Disadvantages:
  - Static dialogue plans, not much work done on those
    --> integrate with ideas in agent-based, where focus on task planning = current research

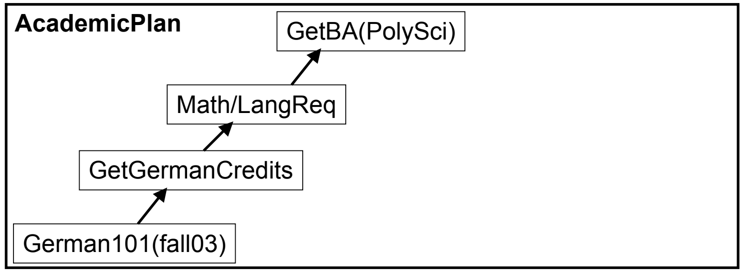
Agent-Based DM

- Communication is a joint activity: Agents communicate to establish common ground
- Collaborative problem solving by (rational) agents
  - Neither agent can accomplish the task alone
  - Need joint goals and mutual understanding
  - Agents collaborate to establish and achieve their goals
- Agents have knowledge about solving tasks
  - deciding on goals (objectives): adopt, select, defer, abandon, release
  - forming plans to achieve goals (recipes)
  - executing those plans (acting)
  - revising decisions (replanning, abandoning goals, etc.)
- Agents reason about beliefs and actions
- Intention recognition

Intention Recognition

Given: plan for getting a BA

U: I'll take German 101 fall semester.



Collaborative Planning&Acting

User: Send ambulance one to Parma right away.
(initiate (c-adopt (action (send amb1 Parma))))
(initiate (c-select (action (send amb1 Parma))))
System: OK. [sends ambulance]
(complete (c-adopt (action (send amb1 Parma))))
(complete (c-select (action (send amb1 Parma))))
System: Where should we take the victim once we pick them up?
(initiate (c-adopt (resource (hospital ?x))))
User: Rochester General Hospital.
(continue (c-adopt (resource (hospital RocGen))))
System: OK.
(complete (c-adopt (resource (hospital RocGen))))

[Blaylock et al. 2003]

Agent-based

- Advantages
  - Flexibility and adaptivity
  - Any task can be modeled
- Disadvantages
  - Intention recognition
  - Lots of reasoning

  --> see QUD-based for "shortcuts"

Current Challenges

Current Challenges

- Adaptivity:
  - Systems need to be dynamically adaptive in a number of different ways: to the environments in which they are used (modality), to their user's preferences and needs (personalisation), and to changes in task and context.
- Ability to learn:
  - Systems need to be able to learn from interactions with users in order to provide an optimally usable interface that matches the current environment and user.
- Standardisation:
  - There is a need for a common set of standards to support re-usability for developers and to support usability for the users of spoken dialogue systems.
- Pervasive systems
  - Systems need to handle distributed dialogues (shifts to different dialogue situations / managers), concurrent dialogues (issues of co-ordination, synchronisation, redundancy); interaction model needs to be predominantly event-based (external events, opportunistic)

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