

Aspects of Information State for Dialogue with Virtual Humans

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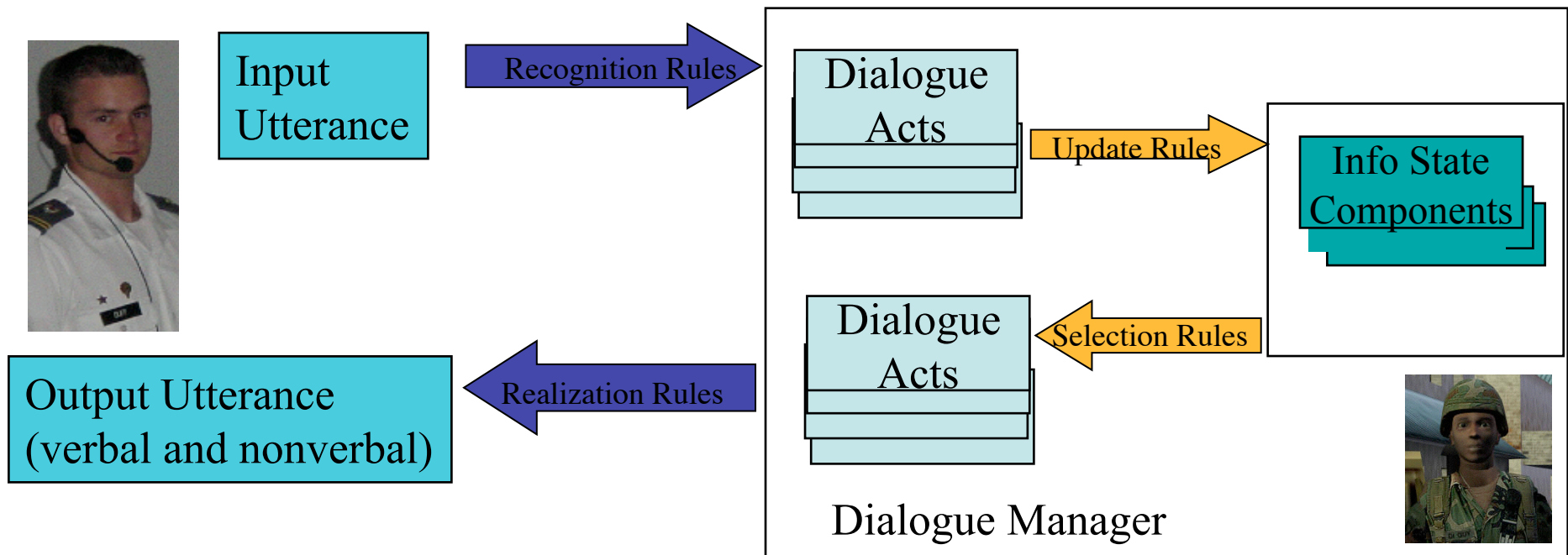


Dialogue Management Tasks

- **Updating Context on observed communication**
- **Deciding what/when to say next**
- **Interface with back-end/task model**
- **Provide expectations for interpretation**

Dialogue Approach: Layered Information State

- **Layer captures coherent aspect of communicative interaction** (e.g., turn, grounding, obligations)
- **Layer consists of**
 - Information State components (state of interaction)
 - Dialogue Acts (Packages of changes to information state)



Dialogue Levels & Dialogue Acts

- **Contact (make,break)**
- **Attention (show, request, accept)**
- **Conversation (begin, join, leave, end)**
 - Turn-taking (take, hold, release, assign)
 - Initiative (take, assign, release)
 - Utterance
 - Main Function (assert, request, suggest, order, offer, promise, info-request,...)
 - Relational (answer, accept, reject, avoid, hold,...)
 - Features: speaker, addressee, overhearer, referent, content
 - Polarity (positive, negative)
 - Grounding (initiate, continue, acknowledge, repair, request repair...)
 - Topic (set topic, set subtopic, close topic)
- **Social**
 - Obligations & Commitments
 - Relationships (Face, Status, Affiliation, Trust)
 - Social Roles

Main Aspects of Dialogue Context

- **Persistent State**

- Social State
- Lexicon
- Ontology
- Speech-event-history

- **Transient**

- Conversation(s)
- Social Planning
- Participants model

- **Other Modules**

- **Task model**
 - Causal-history, current-state
 - Plan,next-step
 - Task focus
- **Emotion Model**
 - Emotional state
 - Coping strategies
- **Perception**
 - Speech
 - vision

Dialogue Processing Cycles

- **Language Interpretation Stages**
 - ASR: 4 message types (speech in, timing/text out)
 - NLU: semantic interpretation(s)
 - Perception: integrated un(der) interpreted speech
 - SOAR Understand Speech Operator
 - SOAR Update Dialogue State Operator
 - SOAR Coping Focus Operator
- **Language Production Stages**
 - Output Speech proposal (desire)
 - pre NLG Output Speech operator (intention)
 - NLG
 - Post NLG output speech
 - XMLify
 - NVB generation
 - Smartbody
 - Synthesizer
 - Post-NLG message passing/callbacks

Limitations

- **Lack of plan reasoning about dialogue**
 - no way to weigh relative costs/benefits of speaking/saying one thing vs another
 - just optimization/action selection
 - Lack of dialogue plan for whole interaction
 - No hypothetical reasoning
- **Very difficult to get new information to system**
 - perception code
 - Levels of indirection
 - Kludgey tcl/soar interface/input-link
- **Difficult to sequence processing decisions**

Developing capabilities

- **More social&cultural modelling/reasoning**
- **Larger set of strategies**
- **Tighter integration with perception, emotion, generation/embodiment**
 - Make use of more information
 - Exploit more synergies
- **Incremental processing and generation**

Task Model: Basic Types

- **States**

- Object-id
- Attribute
- Value
- Polarity

E.g.: :object-id boy :attribute health-status
:value critical-injuries :polarity positive

- **Tasks**

- Pre, Add , Delete (states)
- Case roles (event, agent, patient, location, source, destination, instrument, path)
- E.g.: secure-lz { :agent sgt :patient lz
:event secure :instrument 3rd-sqd
:pre {3rd-sqd-at-aa}
:add {lz-secure lz-marked 3rd-sqd-at-lz}
:del {3rd-sqd-at-aa}}

Proposition and Questions

- **Duran is in the landing zone.**
 - (P1 ^attribute location ^object-id 3s1 ^polarity positive ^time present ^type state ^value lz)
- **Is Duran in the landing zone?**
 - (Q1 ^q-slot polarity ^prop (P2 attribute location ^object-id 3s1 ^time present ^type state ^value lz) ^type question)
- **Where is Duran?**
 - (Q2 ^q-slot value ^prop (P3 attribute location ^object-id 3s1 ^polarity positive ^time present ^type state) ^type question)
- **Who is in the landing zone?**
 - (Q3 ^q-slot object-id ^prop (P4 attribute location ^polarity positive ^time present ^type state ^value lz) ^type question)

Social Roles

- **IS**
 - Status (e.g., Military Rank)
 - Superior
 - equal
 - subordinate
 - Activity roles (e.g., forward observer, pilot)
 - Action-performance roles
 - Actors of parts of complex actions
 - Responsibility (team leadership)
 - Authority
- **Action Effects**
 - Authorize action
 - Perform action
 - Take-up, drop role

Social Commitments

(Traum & Allen94, Allwood 94, Matheson et al 00)

- **IS**
 - Obligations, Social Commitments to Propositions
- **Actions**
 - Order, Request, Suggest
 - Promise, Offer
 - Statement, Question
 - Accept,..
- **Effects are to Obligations & Commitments**
 - Belief updates based on inference, not speech act effects

Social State

- **^obligation + & ;#obligations to act**
 - ^type ^holder ^obligated-to
 - ^action ^deadline ^sanction
- **^commitment + & ;#committed to states of affairs holding**
 - ^type ^holder ^committed-to
 - ^proposition ^sanction
- **^conditional + & ;#obligation or commitment if action**
 - ^type ^trigger ;# an action to check performance of
 - ^consequent ;# the resulting commitment or obligation
- **roles**
 - ^teammate
 - ^superior + & ;# agents superior to self
 - ^subordinate + &) ;# agents subordinate to self

Speech Event History

- **Record of all perceived utterances (regardless of placement in conversations)**
- **Structure**
 - Speech-input (record of processed objects)
 - Last (ordered list of most recent events)
 - Event=speech-input object
 - Previous= rest of list

Grounding

(Clark & Schaeffer 89, Traum 94)

- Signal by B of how s is interpreted
- Possibly revised signals by A
- Grounded state = mutually believed common ground

Label	Description
initiate	Begin new DU, content separate from previous uncompleted DUs
continue	same agent adds related content to open DU
acknowledge	Demonstrate or claim understanding of previous material by other agent
repair	Correct (potential) misunderstanding of DU content
Request Repair	Signal lack of understanding
Request Ack	Signal for other to acknowledge
cancel	Stop work on DU, leaving it ungrounded and ungroundable

Next Act	In State						
	S	1	2	3	4	F	D
initiate^I	1						
continue^I		1			4		
continue^R			2	3			
repair^I		1	1	1	4	1	
repair^R		3	2	3	3	3	
ReqRepair^I			4	4	4	4	
ReqRepair^R		2	2	2	2	2	
ack^I				F	1	F	
ack^R		F	F			F	
ReqAck^I		1				1	
ReqAck^R				3		3	
cancel^I		D	D	D	D	D	
cancel^R			1	1		D	

Dialogue Acts

- **Forward**

- (A1 ^action **info-req** ^actor <speaker> ^addressee <adr>* ^content <Q> ^type csa)
- (A2 ^action **assert** ^actor <speaker> ^addressee <adr>* ^content <P> ^type csa)

- **Backward**

- (A3 ^action **answer** ^actor <speaker> ^addressee <adr>* ^answer <SA> ^question <Q> ^type backward)
- (A4 ^action **clarify-parameter** ^cand <cand>* ^context <SA> ^parameter <role> ^type backward)

- **Grounding**

- (A8 ^action **initiate** ^actor <speaker> ^responder <adr>* ^cgu <cgu> ^content <SA2>* ^conversation <CON>* ^type grounding)
- (A7 ^action **acknowledge** ^actor <speaker> ^cgu <cgu> ^content <SA>* ^conversation <CON> ^type grounding)
- (A5 ^action **repair** ^actor <speaker> ^cgu <cgu> ^content <SA>* ^conversation <CON> ^parameter <role> ^type grounding ^value <filler>)
- (A6 ^action **request-repair** ^actor <speaker> ^cgu <cgu> ^content <SA2>* ^conversation <CON> ^type grounding)

Non-verbal Behavior & communicative functions

Behavior

- Orientation/Gaze

- Pointing

- Head-nod

- Head-shake

Addressee

- Turn

- Referent

- Affiliation

- Grounding

- Answer

- Polarity-positive

- Polarity-negative

Conversation Object

- **^active-participant +&**
- **^overhearer +& ;#^participant is union of active-participant, overhearer**
- **^mode ;# face-to-face, radio,**
- **^last-utterance ;#stack of utterances part of conversation**
- **^dialogue-history + & ;# speech-input objects**
- **^last-mentions ;#history list of mentioned concepts and recency**
- **^initiative ;# one of the active-participants**
- **^turn ;# one of the active participants**
- **^purpose**
- **^QUD**
- **^grounding +&;#set of cgus**
 - **^initiator ;# one of active participants**
 - **^state ;# grounding state: S,F,D,1-4**
 - **^dialogue-history + & ;#core speech acts**
 - **^obligation + & ;#see social state for details**
 - **^commitment + &**
 - **^conditional + &**
 - **^negotiation-stance + & ;#negotiation objects**

Social Planning

- **Expectations**
 - Reactions to suggestions
 - Task-related moves
- **Agenda**
 - Partially ordered set of desired moves
 - Conversational Strategy

Lexicon

- **Used to map ASR/NLU tokens to internal tokens (specialized to domain/task)**
- **Types:**
 - Actions, events
 - Attributes, entities, locations, times, values
- **Examples**
 - ^lexicon.entities.1sldr martin
 - ^lexicon.entities.1sldr 1sldr
 - ^lexicon.location.aa assembly
 - ^lexicon.location.aa area

Ontology

- **Purpose: Typing/structuring of concepts**
 - Selectional restrictions of semantic events
 - Group membership
- **Aspects:**
 - Event-types, events (calculated from task defs)
 - Group, human, location, vehicle (currently added manually)
 - Groups : link group to member (used in inference)
 - Type-slots: (e.g., recon)
 - Necessary slots (e.g, agent, event, time)
 - Possible slots:
 - (agent,destination,event,instrument,path,source,time)

Understand Speech Operator

- **Triggered by complete speech input event**
 - Human (ASR,NLU)
 - Agent (vrSpeech,vrNLU)
 - Self (autonomous “event” from generation)
- **Main Purposes:**
 - Adjust semantic interpretation using soar-internal context (task, language and situation specific)
 - Reference resolution (pick out acts, entities, concepts mentioned)
 - Detect uninterpretable or ambiguous/underspecified content
 - Recognize dialogue acts

Example: SOAR Understanding Rule

```
#recognize order from imperative from superior
sp {top-state*apply*operator*understand-speech*imperative-superior->order
  (state <s> ^name top-state          ^social-state.status <ss>    ^operator <o>)
  (<o> ^name understand-speech    ^speech-input <si>)
  (<si> ^id <id>    ^speaker <speaker>    ^interpretation <i>)
  (<i> ^addressee <hearer>    ^mood imperative    ^semantics <sem> )
  -{(<i> ^token.lex << say >>    ^token.lex << again >>)}
  (<ss> ^<hearer> <sadr>)
  (<sadr> ^superior <speaker>)
-->
  (<i> ^speech-act <csa> + &)
  (<csa> ^type csa          ^action order
    ^actor <speaker>    ^addressee <hearer>
    ^content <sem>)
}
```

Update Dialogue State Operator

- **Triggered by Interpreted Speech Input**
- **Purpose:**
 - Update context by calculating effects of dialogue acts

Example: Soar Update rule

```
sp {top-state*apply*operator*update-dialogue-state*csa*order
  (state <s> ^name top-state      ^operator <o>)
  (<o> ^name update-dialogue-state ^speech-input <si>)
  (<si> ^speaker <speaker>      ^interpretation <i>)
  (<i> ^conversation <c>      ^speech-act <csa>)
  (<c> ^grounding <cgu>)
  (<cgu> ^dialogue-history <csa>)
  (<csa> ^action order      ^content <sem>      ^addressee <addr>)
  -->
  (<cgu> ^obligation <obl> + &)
  (<obl> ^type obligation      ^holder <addr>
    ^obligated-to <speaker>      ^deadline asap
    ^sanction order      ^action <sem>)
}
```

NLG Approach

- **Asynchronous Communicative Goal Proposal**
- **Selection of Goal**
- **Content planning**
- **Realization: Hybrid Approach**
 - Rule-based prompts & templates
 - Framebank-based semantics
 - Statistical classification
 - Grammar-based

Selecting Speech Acts to Perform

- **Considerations:**

- The turn
- Initiative
- focus
- Obligations to ground
- Obligations to repair
- Degree of understanding of prior utterances
- (potential) obligations to address info-request
- Beliefs about true answers
- Goals
- Negotiation Strategy

Output Speech Operator

- **Triggered by (successful) desire to speak**
- **Main Purposes**
 - Deliberation over how to achieve communication goal
 - Content planning
 - Sentence planning
 - Realization
 - Selection
 - Produce speech & wait for callback

Example Output Speech Rule

```
sp {top-state*propose*operator*output-speech*accept-obligation-to-act
  (state <s> ^name top-state ^agent-name <me> ^conversation <c>
    ^social-planning <sp>)
  (<sp> ^my-potential-obligation <obl>)
  (<obl> ^obligated-to <other> ^action <a>
    ^dialogue-state needs-discussion ^relevant-party <me>
    ^plan-state << good considered-good not-in-coa >>)
  (<c> -^turn <other> ^grounding <cgu1>
    ^participant <me> ^participant <other>)
  (<cgu1> ^dialogue-history <order>)
  (<order> ^action << order request >> ^actor <other>
    ^addressee <me> ^content <a>)
  -->
  (<s> ^operator <o> + =)
  (<o> ^name output-speech ^priority-class respond
    ^conversation <c> ^goal <b>)
  (<b> ^action accept
    ^type backward
    ^addressee <other>
    ^speaker <me>
    ^content <order>)
}
```

Team Negotiation (Traum et al AAMAS 2003)

- **IS: task (&CGU) annotated with negotiation objects**
 - Components: Agent, Action, Stance, audience, reason
 - Stances: Committed, endorsed, mentioned, not mentioned, disparaged, rejected
- **Action effects:**
 - Suggestion: mentioned
 - command, promise, request, or acceptance: committed
 - Rejection: rejected
 - Counterproposal: disparaged₁ + endorsed₂
 - Justification: endorsed or disparaged (depending on direction)
 - Offer: mention (conditional commitment)
 - Retract stance
- **Factors:**
 - Relevant Party: Authorizing or Responsible Agent
 - Dialogue State: who has discussed
 - Plan State: how do I feel about it

SASO-EN Multiparty Negotiation

- **Set of Strategies**
- **Multiparty**
 - Each agent has strategy
 - Trust toward each party
- **Multi-issue**
 - Appraisal for each alternative
 - Potential strategy for each
 - Topic tracking
 - Strategy for current topic is active
- **Negotiation Considerations**
 - Trust
 - If too low, disengage
 - Plan Assessment
 - Appraisal variables
 - Flaws
 - Relative utility
 - Dialogue Assessment
 - Topic
 - Control
 - Commitments

SASO VHuman Trust Model

(Traum et al, IVA 2005)

- **Trust as function of multiple factors:**
 - Familiarity - can I expect someone to behave properly
 - Solidarity - to what extent does other have shared purpose with me
 - Credibility - does agent make (only) claims that
 - Are believable
 - Are verifiably true
 - Turn out to be true
- **Trust dynamically computed**
 - Displays of solidarity/opposed goals
 - Credible/incredible statements
 - Show empathy, polite behavior, behave according to conventions
- **Use of trust**
 - accept assertions as truth (e.g., Perrault, Cohen & Allen)
 - Negotiate in good faith
 - Continue engagement
 - Acceptance/Rejection of empathy (Martinovski et al)

Implementing Negotiation Strategies

- **Orientations result from appraisal of negotiation**
 - Reified negotiation “task”
 - Interactions with goals and plans
- **Strategies chosen as part of coping**
 - Entry & exit conditions
- **Strategies associated with communicative behavior**
 - Base posture and gesture set
 - Choice of dialogue moves
 - Speech act and realization
 - Initiative, topic selection, and type of grounding feedback
 - Affective tone
 - Aspects of interpretation
 - Charitability of interpretation
 - Assumptions vs clarification

Negotiation Strategies: Appraising the topic

	topic	Control	Utility	Potential	Trust	Commitment
Find issue	--				some	
Avoid		+	--		some	
Attack	+	--	--	--	some	
Negotiate	+	--	--	+	some	
Advocate	+		+		some	
Success	+				moderate	Mutual
Failure	+				Very low	Negative

Behaving according to Strategies

- **Find Issue**
 - Find topic
- **Avoid**
 - Change topic
 - Try to leave
- **Attack**
 - State flaws
 - Propose better alternatives
 - Ad hominem
- **Negotiate**
 - State flaws
 - Propose solutions
 - Offer bargains
- **Advocate**
 - Propose actions
 - Address flaws
 - Offer commitment
- **Success**
 - Move on
- **Failure**
 - Move on