Spoken Dialogue Systems: Managing Interaction

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Outline

- ‘Rules’ of Human-Human Conversation
  - Turn-taking
  - Speech Acts
  - Grounding
- Dialogue Management in SDS
  - Types of Dialogue Management
  - Varieties of Initiative
- VoiceXML

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Turn-taking

- Dialogue is characterized by turn-taking.
  - A:
  - B:
  - A:
  - B:
  - …
- Resource allocation problem
- How do speakers know when to take the floor?
  - Total amount of overlap relatively small (5% - Levinson 1983)
  - But there is very little pause
  - Must be a way to know who should talk and when

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Turn-taking rules

- At each transition-relevance place (TRP) of each turn:
  - a) If during this turn the current speaker has selected B as the next speaker, then B must speak next.
  - b) If the current speaker does not select the next speaker, any other speaker may take the next turn.
  - c) If no one else takes the next turn, the current speaker may take the next turn.

Implications of Subrule a

- For some utterances, current speaker selects next speaker
  - Adjacency pairs
    - Question/answer
    - Greeting/greeting
    - Compliment/downplayer
    - Request/grant
- Silence between 2 parts of adjacency pair is different than silence after
  - A: Is there something bothering you or not?
  - (1.0)
  - A: Yes or no?
  - (1.5)
  - A: Eh?
  - B: No.

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Speech Acts

- Austin (1962): An utterance is a kind of action
- Clear case: performatives
  - I name this ship the Titanic
  - I second that motion
  - I bet you five dollars it will snow tomorrow
- Performative verbs (name, second, bet…)
- Austin's idea: not just these verbs

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Each utterance is 3 acts

- Locutionary act: the utterance of a sentence with a particular meaning
- Illocutionary act: the act of asking, answering, promising, etc., in uttering a sentence.
- Perlocutionary act: the (often intentional) production of certain effects upon the thoughts, feelings, or actions of addressee in uttering a sentence.

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Locutionary vs. Illocutionary vs. Perlocutionary

- “You can’t do that!”
- Illocutionary force:
  - Protest
- Perlocutionary force:
  - Intent to annoy addressee
  - Intent to stop addressee from doing something

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Illocutionary Acts

- How many are there?
- What are they?
- How do we decide?

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Some Ideas from Searle (1975): Speech Acts

- **Assertives**: **Commitments** by the speaker to something's being the case
  - *suggesting, putting forward, swearing, boasting, concluding*
- **Directives**: **Attempts** by the speaker to get the addressee to do something
  - *asking, ordering, requesting, inviting, advising, begging*
- **Commissives: Commitments** by the speaker to some future course of action
  - *promising, planning, vowing, betting, opposing*
- **Expressives**: **Expressions** of the psychological state of the speaker about a state of affairs
  - *thanking, apologizing, welcoming, deploring*
- **Declarations**: **Utterances** by the speaker that themselves bring about a different state of the world
  - *I resign; You're fired; I now pronounce you…)*

Grounding

- Assumption: Dialogue is a collective act performed by speaker (S) and hearer (H)
- Common ground: set of things mutually believed by both speaker and hearer
- S and H need to achieve common ground to achieve successful communication, so H must ground or acknowledge S's utterance
- Clark (1996):
  - Principle of closure. Agents performing an action require evidence, sufficient for current purposes, that they have succeeded in performing it
  - True in HCI as well (Norman,1988)
  - Need to know whether an action succeeded or failed

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Clark and Schaefer: Types of Grounding

- Continued attention: B continues attending to A
- Relevant next contribution: B starts in on next relevant contribution
- Acknowledgement: B nods or says continuer like *uh-huh*, *yeah*, assessment (*great!*)
- Demonstration: B demonstrates understanding A by paraphrasing or reformulating A's contribution, or by collaboratively completing A's utterance
- Display: B displays verbatim all or part of A's presentation

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A human-human conversation

C_1:	. . . I need to travel in May.
A_1:	And, what day in May did you want to travel?
C_2:	OK uh I need to be there for a meeting that's from the 12th to the 15th.
A_2:	And you're flying into what city?
C_3:	Seattle.
A_3:	And what time would you like to leave Pittsburgh?
C_4:	Uh hmm I don't think there's many options for non-stop.
A_4:	Right. There's three non-stops today.
C_5:	What are they?
A_5:	The first one departs PGH at 10:00am arrives Seattle at 12:05 their time. The second flight departs PGH at 5:55pm, arrives Seattle at 8pm. And the last flight departs PGH at 8:15pm arrives Seattle at 10:28pm.
C_6:	OK I'll take the 5ish flight on the night before on the 11th.
A_6:	On the 11th? OK. Departing at 5:55pm arrives Seattle at 8pm, U.S. Air flight 115.
C_7:	OK.

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Grounding examples

- Display:
  - C: I need to travel in May
  - A: *And*, what day in May did you want to travel?
- Acknowledgement
  - C: He wants to fly from Boston
  - A: mm-hmm
  - C: to Baltimore Washington International
  - [Mm-hmm (usually transcribed “uh-huh”) is a backchannel, continuer, or acknowledgement token]

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- Acknowledgement + next relevant contribution
  - And, what day in May did you want to travel?
  - And you're flying into what city?
  - And what time would you like to leave?
- The *and* indicates to the client that agent has successfully understood answer to the last question.

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Grounding negative responses

From Cohen et al. (2004)

- System: Did you want to review some more of your personal profile?
- Caller: No.
- System: Okay, what's next?

Good!

- System: Did you want to review some more of your personal profile?
- Caller: No.
- System: What's next?

Bad!

Grounding and Dialogue Systems

- Grounding is not just a useful fact about humans
- Key to designing a good conversational agent
- Why?

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Grounding and Dialogue Systems

- Grounding is not just a tidbit about humans
- Is key to design of conversational agent
- Why?
  - HCI researchers find users of speech-based interfaces are confused when system doesn't give them an explicit acknowledgement signal
  - Stifelman et al. (1993), Yankelovich et al. (1995)

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Dialogue Manager

- Controls the architecture and structure of dialogue
  - Takes input from ASR/NLU components
  - Maintains some sort of state
  - Interfaces with Task Manager
  - Passes output to NLG/TTS modules

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Architectures for Dialogue Management

- Finite State
- Frame-based
- Information State
  - Markov Decision Processes
- AI Planning

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Finite-State Dialogue Management

- A trivial airline travel system
  - Ask the user for a departure city
  - For a destination city
  - For a time
  - Whether the trip is round-trip or not

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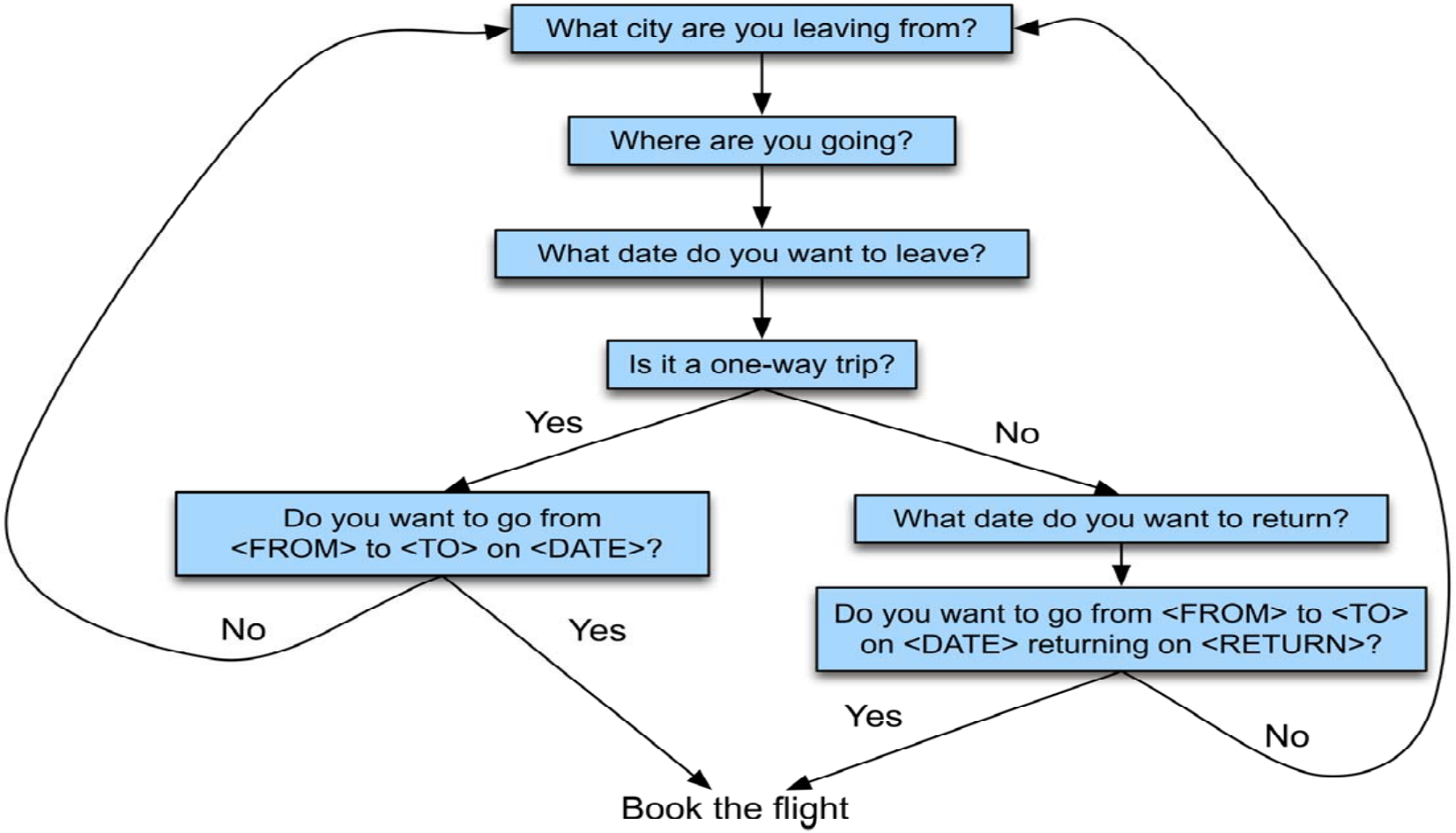
Finite State Dialogue Manager



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Finite-state Dialogue Managers

- System completely controls the conversation with the user
- Asks the user a series of questions
- Ignores (or misinterprets) anything the user says that is ***not*** a direct answer to the system's questions

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Dialogue Initiative

- Systems that control conversation like this are system initiative or single initiative
- "Initiative": who has control of conversation
- In normal human-human dialogue, initiative shifts back and forth between participants

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System Initiative SDS

- Advantages:
  - Simple to build
  - User always knows what they can say next
  - System always knows what user can say next
    - Known words: Better performance from ASR
    - Known topic: Better performance from NLU
  - Ok for very simple tasks (entering a credit card, or login name and password)
- Disadvantage:
  - Too limited

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Major Problems with System Initiative

- Real dialogue involves give and take
- In travel planning, e.g., users might want to say something that is not the direct answer to the question
- E.g.
  - System: What city do you want to leave from?
  - User1: Hi, I'd like to fly from Seattle Tuesday morning
  - User2: I want a flight from Milwaukee to Orlando one way leaving after 5 p.m. on Wednesday.

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One Option: Single initiative + Universals

- Give users a little more flexibility by adding universal commands
- Universals: commands you can say anywhere
- Augment every state of FSA with these options:
  - Help
  - Start over
  - Correct
- This describes many implemented systems
- But still doesn't allow user to say what they want to say

User Initiative

- User directs the system
- Generally, user asks a single question, system answers
- System can't ask questions back, engage in clarification dialogue, confirmation dialogue
- Used for simple database queries
  - User asks a question, system gives an answer
  - E.g., Web search is user initiative dialogue

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Mixed Initiative

- Conversational initiative can shift between system and user
- Simplest kind of mixed initiative: use structure of a frame to guide dialogue: goal is fill in the slots by asking the questions
  - Slot — Question
  - ORIGIN — What city are you leaving from?
  - DEST — Where are you going?
  - DEPT DATE — What day would you like to leave?
  - DEPT TIME — What time would you like to leave?
  - AIRLINE — What is your preferred airline?

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Defining Mixed Initiative

- Mixed Initiative could mean
  - User can arbitrarily take or give up initiative in various ways
    - Only possible in very complex plan-based dialogue systems
    - No commercial implementations
    - Important research area
  - Something simpler and quite specific

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Mixed-Initiative Frame-based Systems

- User can answer multiple questions at once
- System asks questions to fill in remaining slots
- When frame is filled, we're done!
  - Do database query
- If user answers 3 questions at once, system fills in those slots and doesn't ask the slot questions
- Advantages:
  - Avoid strict constraints on order of the finite-state architecture
  - Faster but riskier!

Systems with Multiple frames

- E.g., flights, hotels, rental cars
- Subframes, e.g. Flight legs: Each flight can have multiple legs, which might need to be discussed separately
- Multiple instantiations: e.g. Presenting multiple flights meeting users constraints
  - Slots like 1ST_FLIGHT or 2ND_FLIGHT so user can ask “how much is the second one”
- General route information:
  - Which airlines fly from Boston to San Francisco?
- Airfare practices:
  - Do I have to stay over Saturday to get a decent airfare?

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Problems with Multiple Frames

- Need to be able to switch from frame to frame – how?
  - Based on what user says?
  - Based on likelihood of frame sequence
- Disambiguate which slot of which frame an input is supposed to fill, then switch dialogue control to that frame.
- Main implementation: production rules
  - Different types of inputs cause different productions to fire
  - Each of which can flexibly fill in different frames
  - Can also switch control to different frame

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True Mixed Initiative

C_1:	. . . I need to travel in May.
A_1:	And, what day in May did you want to travel?
C_2:	OK uh I need to be there for a meeting that's from the 12th to the 15th.
A_2:	And you're flying into what city?
C_3:	Seattle.
A_3:	And what time would you like to leave Pittsburgh?
C_4:	Uh hmm I don't think there's many options for non-stop.
A_4:	Right. There's three non-stops today.
C_5:	What are they?
A_5:	The first one departs PGH at 10:00am arrives Seattle at 12:05 their time. The second flight departs PGH at 5:55pm, arrives Seattle at 8pm. And the last flight departs PGH at 8:15pm arrives Seattle at 10:28pm.
C_6:	OK I'll take the 5ish flight on the night before on the 11th.
A_6:	On the 11th? OK. Departing at 5:55pm arrives Seattle at 8pm, U.S. Air flight 115.
C_7:	OK.

Implementing a Mixed Initiative System

- Two criteria:
- Open prompts vs. directive prompts
- Restrictive versus non-restrictive grammar

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Open vs. Directive Prompts

- Open prompt
  - System gives user very few constraints
  - User can respond how they please:
  - "How may I help you?" "How may I direct your call?"
- Directive prompt
  - Explicit instructs user how to respond
  - "Say yes if you accept the call; otherwise, say no"

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Restrictive vs. Non-restrictive grammars

- Restrictive grammar
  - Language model which strongly constrains the ASR system, based on dialogue state
- Non-restrictive grammar
  - Open language model which is not restricted to a particular dialogue state

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Definition of Mixed Initiative

Grammar	Open Prompt	Directive Prompt
Restrictive	*Doesn't make sense*	System Initiative
Non-restrictive	User Initiative	Mixed Initiative

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VoiceXML

- Voice eXtensible Markup Language
- An XML-based dialogue design language
- Makes use of ASR and TTS
- Deals well with simple, frame-based mixed initiative dialogue.
- Most common in commercial world (too limited for research systems)
- But useful to get a handle on the concepts

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Voice XML

- Each dialogue is a <form>. (Form is the VoiceXML word for frame)
- Each <form> generally consists of a sequence of <field>s, with other commands

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Sample VXML Form

```
<form>
  <field name="transporttype">
     <prompt>
        Please choose airline, hotel, or rental car.  </prompt>
     <grammar type="application/x=nuance-gsl">
      [airline hotel "rental car"]
     </grammar>
  </field>
  <block>
    <prompt>
     You have chosen <value expr="transporttype">. </prompt>
  </block>
</form>
```


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VoiceXML interpreter

- Walks through a VXML form in document order
- Iteratively selecting each item
- If multiple fields, visit each one in order
- Special commands for events

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Reprompting Forms

<noinput>
I'm sorry, I didn't hear you. <reprompt/>
</noinput>
- "noinput" means silence exceeds a timeout threshold

<nomatch>
I'm sorry, I didn't understand that. <reprompt/>
</nomatch>

- "nomatch" means confidence value for utterance is too low
- notice "reprompt" command

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Welcome Form

```
<form>
  <block>    Welcome to the air travel consultant.  </block>
  <field name="origin">
     <prompt>     Which city do you want to leave from?  </prompt>
     <grammar type="application/x=nuance-gsl">
       [(san francisco) denver (new york)  barcelona]
     </grammar>
     <filled>
       <prompt>  OK, from <value expr="origin">  </prompt>
     </filled>
  </field>
```

- “filled” tag is executed by interpreter as soon as field filled by user

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```
<field name="destination">
    <prompt>  And which city do you want to go to?   </prompt>
    <grammar type="application/x=nuance-gsl">
      [(san francisco) denver (new york)  barcelona]
    </grammar>
    <filled>
      <prompt>   OK, to <value expr="destination">   </prompt>
    </filled>
  </field>
  <field name="departdate" type="date">
    <prompt>  And what date do you want to leave?  </prompt>
    <filled>
      <prompt>   OK, on <value expr="departdate">   </prompt>
    </filled>
  </field>
```


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Summing Up

```
<block>
    <prompt> OK, I have you are departing from
        <value expr="origin”>  to <value expr="destination”> on <value
    expr="departdate">
    </prompt>
    send the info to book a flight...
  </block>
</form>
```


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Summary

- Human-human conversation
  - Turn-taking
  - Speech Acts
  - Grounding
  - Error Handling and Help
- Dialogue Manager Design
  - Finite State
  - Frame-based
  - Initiative: User, System, Mixed
- VoiceXML

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Next Class

- Information State and Dialogue Acts