Dialogue Systems
NPFL123 Dialogové systémy

2. What happens in a dialogue

Ondřej Dušek & Ondřej Plátek & Jan Cuřín
ufal.cz/npfl123
26. 2. 2019
How do you “define” dialogue?

Spoken/written conversational (interactive, collaborative) communication between two or more people

- **verbal** + (possibly) non-verbal
  - can be multimodal (language + gestures, pitch, expressions…)
- **collaborative**, social
  - participants aim at communicative goal(s)
  - involves inference about intended meanings
- **practical**, related to actions
- **interactive**, incremental, messy!

Dialogue systems – simpler than that
Describing a dialogue

- Levels of linguistic description
  - **phonetics / phonology** – sounds
  - **morphology** – word forms
  - **syntax** – sentence structure
  - **semantics** – sentence (propositional) meaning
  - **pragmatics** – meaning in context, communication goal

- This lecture is (a lot) about **pragmatics**

(I don’t remember it well)

http://lindat.mff.cuni.cz/services/udpipe/

http://cohort.inf.ed.ac.uk/amreager.html
Turn-taking (interactivity)

• Speakers **take turns** in a dialogue
  • **turn** = continuous utterance from one speaker

• Normal dialogue – very fluent, fast
  • minimizing **overlaps & gaps**
    • little silence (usually <250ms), little overlap (~5%)
    • (fuzzy) rules, anticipation
  • cues/markers for turn boundaries:
    • linguistic (e.g. finished sentence), voice pitch
    • timing (gaps)
    • eye gaze, gestures (…)

• overlaps happen naturally
  • ambiguity in turn-taking rules (e.g. two start speaking at the same time)
  • **barge-in** = speaker starts during another one’s turn
Turn-taking (example)

20 seconds of a semi-formal dialogue (talk show):

S: um uh , you're about to start season [six ,]
J: [yes]
S: you probably already started but [it launches]
J: [yes thank you]
A: (cheering)
J: we're about to start thank you yeah .. we're starting , we- on Sunday yeah , we've been eh- we've been prepping some [things]
S: [confidence] is high . feel good ?
J: (scoffs)
S: think you're gonna [squeeze out the shows this time ? think you're gonna do it ?]
J: (Laughing) [you're talking to me like I'm an a-] confidence high ? no !
S: [no]
J: [my confidence] is never high .
S: okay
J: self loathing high . concern astronomic .
Speech vs. text

- Natural speech is **very different from written text**
  - ungrammatical
  - restarts, hesitations, corrections
  - overlaps
  - pitch, stress
  - accents, dialect
- See more examples in speech corpora
  - [https://kontext.korpus.cz/](https://kontext.korpus.cz/) (Czech)
  - select the “oral” corpus and search for a random word
Turn taking in dialogue systems

• consecutive turns are typically assumed
  • system waits for user to finish their turn (~250ms non-speech)

• voice activity detection
  • binary classification problem – “is it user’s speech that I’m hearing?”[Y/N]
  • segments the incoming audio (checking every $X$ ms)
  • actually a hard problem
    • nothing ever works in noisy environments

• wake words – making VAD easier
  • listen for a specific phrase, only start listening after it

• some systems allow user’s barge-in
  • may be tied to the wake word
Speech acts  
(by John L. Austin & John Searle)

• each utterance is an act
  • intentional
  • changing the state of the world
    • changing the knowledge/mood of the listener (at least)
    • influencing the listener’s behavior

• speech acts consist of:
  a) utterance act = the actual uttering of the words
  b) propositional act = semantics / “surface” meaning
  c) illocutionary act = “pragmatic” meaning
    • e.g. command, promise [...]
  d) perlocutionary act = effect
    • listener obeys command, listener’s worldview changes [...]

X to Y: You’re boring!
 a) [jʊəˈbɔːrɪŋ]
 b) boring(Y)
 c) statement
 d) Y is cross

X to Y: Can I have a sandwich?
 a) [kæn ə hæv əˈsændwɪtʃ]
 b) can_have(X, sandwich)
 c) request
 d) Y gives X a sandwich
Speech acts

• Types of speech acts:
  • **assertive**: speaker commits to the truth of a proposition
    • statements, declarations, beliefs, reports […]
  • **directive**: speaker wants the listener to do something
    • commands, requests, invitations, encouragements
  • **commissive**: speaker commits to do something themselves
    • promises, swears, threats, agreements
  • **expressive**: speaker expresses their psychological state
    • thanks, congratulations, apologies, welcomes
  • **declarative**: performing actions (“performative verbs”)
    • sentencing, baptizing, dismissing

It’s raining outside.
Stop it!
I’ll come by later.
Thank you!
You’re fired!
Speech acts

• Explicit vs. implicit
  • explicit – using a verb directly corresponding to the act
  • implicit – without the verb

• Direct vs. indirect
  • indirect – the surface meaning does not correspond to the actual one
    • primary illocution = the actual meaning
    • secondary illocution = how it’s expressed
  • reasons: politeness, context, familiarity

explicit: I promise to come by later.
implicit: I’ll come by later.

explicit: I’m inviting you for a dinner.
implicit: Come with me for a dinner!

direct: Please close the window.
indirect: Could you close the window?
even more indirect: I’m cold.

direct: What is the time?
indirect: Have you got a watch?
Conversational Maxims (by Paul Grice)

• based on Grice’s **cooperative principle** (“dialogue is cooperative”)
  • speaker & listener cooperate w. r. t. communication goal
  • speaker wants to inform, listener wants to understand

• 4 Maxims (basic premises/principles/ideals)
  • M. of **quantity** – don’t give too little/too much information
  • M. of **quality** – be truthful
  • M. of **relation** – be relevant
  • M. of **manner** – be clear

• By default, speakers are assumed to adhere to maxims
  • apparently breaking a maxim suggests a different/additional meaning
Conversational Implicatures

- **implicatures** = implied meanings
  - standard – based on the assumption that maxims are obeyed
  - maxim flouting (obvious violation) – additional meanings (sarcasm, irony)

John ate some of the cookies → [otherwise too little/low-quality information] not all of them

A: I’ve run out of gas.
B: There’s a gas station around the corner. → [otherwise irrelevant] the gas station is open

A: Will you come to lunch with us?
B: I have class. → [otherwise irrelevant] B is not coming to lunch

A: How’s John doing in his new job?
B: Good. He didn’t end up in prison so far. → [too much information] John is dishonest / the job is shady
Speech acts & maxims & implicatures in dialogue systems

- Learned from data / hand-coded
- Understanding
  - tested on real users → usually knows indirect speech acts
  - implicatures limited – there’s no common sense
    - (other than what’s hand-coded or found in training data)
- Responses
  - mostly strive for clarity – user doesn’t really need to imply

**system:** The first train from Edinburgh to London leaves at 5:30 from Waverley Station.
**user:** I don’t want to get up so early. → [fails]
Grounding

• dialogue is cooperative → need to ensure mutual understanding

• **common ground** = shared knowledge, mutual assumptions of dialogue participants
  • not just shared, but *knowingly* shared
  • \( x \in \text{CG}(A, B) \):
    • A & B must know \( x \)
    • A must know that B knows \( x \) and vice-versa
  • expanded/updated/refined in an informative conversation

• validated/verified via **grounding signals**
  • speaker *presents* utterance
  • listener *accepts* utterance by providing evidence of understanding
Grounding signals / feedback

• used to notify speaker of (mis)understanding

• positive – understanding/acceptance signals:
  • **visual** – eye gaze, facial expressions, smile […]
  • **backchannels** – particles signalling understanding
  • **explicit feedback** – explicitly stating understanding
  • **implicit feedback** – showing understanding implicitly in the next utterance

• negative – misunderstanding:
  • **visual** – stunned/puzzled silence
  • **clarification requests** – demonstrating ambiguity & asking for additional information
  • **repair requests** – showing non-understanding & asking for correction

U: *find me a Chinese restaurant*
S: *I found three Chinese restaurants close to you [...]*

A: *Do you know where John is?*
B: *John? Haven’t seen him today.*

```
I know, Yes I understand
```

```
uh-uh, hmm, yeah
```

```
Oh, so you’re not flying to London? Where are you going then?
```
Grounding (example)

T: [...] And the ideology is also very against mixed-race couples. So that was also a target. Whenever we saw mixed-race couples, we attacked them.

E: Was there ever a moment back there where you felt a tiny bit bad about it?
T: No.
E: No? So you were absolutely convinced that you're doing the right thing…
T: Yeah, for quite some time (nods), yeah.
E: … for the sake of the white race and et cetera?
E: No doubt at all?
T: Well I got doubt eventually, roughly a year before I left the movement [...]
Grounding in dialogue systems

• Crucial for successful dialogue
  • e.g. booking the right restaurant / flight

• Backchannels / visual signals typically not present

• **Implicit confirmation** very common
  • users might be confused if not present

• **Explicit confirmation** may be required for important steps
  • e.g. confirming a reservation / bank transfer

• **Clarification & repair requests** very common
  • when input is ambiguous or conflicts with previously said

• Part of dialogue management
  • uses NLU confidence in deciding to use the signals
Deixis

• **deixis** = “pointing” – relating between language & context/world
  • this is very important in dialogue
  • dialogue is typically set/situated in a specific context

• **deictic expressions** = words/grammar expressing deixis
  • their meaning depends on the context
    • who is talking, when, where
  • pronouns  
    • *I, you, him, this*  
  • verbs: tense & person markers  
    • *goes* [3rd ps. sg.], *went* [past]
  • adverbs  
    • *here, now, yesterday*
  • other (lexical meaning)  
    • *come / go* [=here/away],
  • non-verbal (gestures, gaze…)
Deixis

• (typically) **egocentric**: *I – here – now* is the center (**origo**)

• main types of deixis:
  • **personal** – *I/me/you/she…*
  • **temporal** (time) – *now, yesterday, later, on Monday…*
  • **local** (space) – *here, there…*

• other:
  • **social** (politeness)
    • formal/informal address (Cz. *ty/vy*, Ger. *du/Sie*), honorifics in Asian languages
  • **discourse/textual**
    • referring to words/portions of texts – *next chapter, how do you spell that?*
Anaphora/Coreference

- expression referring to something mentioned in context
  - **anaphora** = referring back
  - **cataphora** = referring forward
- avoiding repetition, faster expression
- can refer to basically anything
  - objects/persons/events
  - qualities
  - actions/full sentences/portions of text
- used frequently in dialogue
- may be ambiguous

Susan dropped the plate. **It** shattered.

His friends describe John as smart and hard-working.

Her dress is green. **So** is mine.

I don’t like it as much as **he** does.

Bill stands next to John. **He** is tall.

Bill tickled John. **He** squirmed.

- Shall I book a room for you? – Sure, I’d like **that**.
Deixis & anaphora in dialogue systems

• systems typically assume a **single user**
  • this makes personal deixis much easier

• most systems are aware of time, location is more complicated
  • pronouns are often avoided – clearer, although less natural

• coreference resolution – separate problem
  • a whole area of research, specific resolution systems developed
  • some dialogue systems don’t include it, some do, sophistication varies
Prediction

• Dialogue is a **social interaction**
  • people view dialogue partners as goal-directed, intentional agents
  • they analyze their partners’ goals/agenda

• Brain does not listen passively
  • projects hypotheses/interpretations on-the-fly

• **prediction** is crucial for human cognition
  • people predict what their partner will (or possibly can) say/do
  • continuously, incrementally
  • unconsciously, very rapidly
  • guides the cognition

• this is (part of) why we understand in adverse conditions
  • noisy environment, distance
Entropy (Claude Shannon)

• Information theory: dialogue is information transfer
  • **communication channel** – speaker to listener (in the given situation)
  • **entropy** – expected value of information conveyed (in bits)

  \[ H(\text{text}) = - \sum_{x \in \text{text}} \frac{\text{freq}(x)}{\text{len}(\text{text})} \log_2 \left( \frac{\text{freq}(x)}{\text{len}(\text{text})} \right) \]

• Plays well with the social interaction perspective
  • people tend to **use all available channel capacity**
    • limiting factors: noise, listener’s hearing ability, mental capacity
  • people tend to **spread information evenly**
    • words carrying more information are emphasized

\[ XXXX \text{ – entropy 0} \]
\[ WXYZ \text{ – entropy 2} \]
Prediction in dialogue systems

• Used a lot in speech recognition
  • **language models** – based on information theory
    • statistical, trained on a text corpus (bunch of texts)
    • predicting likely next word given context
    • weighted against acoustic information

• Not as good as humans
  • may not reflect current situation (noise etc.)
  • (often) does not adapt to the speaker

• Less use in other DS components
Alignment/entrainment

• People subconsciously adapt/align/entrain to their dialogue partner over the course of the dialogue
  • wording (lexical items)
  • grammar (sentential constructions)
  • speech rate, prosody, loudness
  • accent/dialect

  • This helps a successful dialogue
    • also helps social bonding, feels natural

S: […] Confidence is high, feel good?
J: Confidence high? No!
S: No.
J: My confidence is never high.
S: Okay.
J: Self loathing high, concern astronomic.

pram → stroller [BrE speaker
lorry → truck talking to AmE speaker]
Alignment in dialogue systems

- Systems typically don’t align
  - NLG is rigid
    - templates
    - machine learning trained without context
  - experiments: makes dialogue more natural

- People align to dialogue systems
  - same as when talking to people

<table>
<thead>
<tr>
<th>Words</th>
<th>D1 Freq. (% rel. Freq)</th>
<th>D2 freq (% rel. Freq)</th>
</tr>
</thead>
<tbody>
<tr>
<td>V1: next</td>
<td>13204 (99.9%)</td>
<td>492 (82.9%)</td>
</tr>
<tr>
<td>V2: following</td>
<td>3 (0.1%)</td>
<td>101 (17.1%)</td>
</tr>
<tr>
<td>V1: previous</td>
<td>3066 (100%)</td>
<td>74 (44.8%)</td>
</tr>
<tr>
<td>V2: preceding</td>
<td>0 (0%)</td>
<td>96 (55.2%)</td>
</tr>
<tr>
<td>V1: now</td>
<td>6241 (99.8%)</td>
<td>237 (80.1%)</td>
</tr>
<tr>
<td>V2: immediately</td>
<td>10 (0.2%)</td>
<td>59 (19.9%)</td>
</tr>
<tr>
<td>V1: leaving</td>
<td>4843 (98.4%)</td>
<td>165 (70.8%)</td>
</tr>
<tr>
<td>V2: departing</td>
<td>81 (1.6%)</td>
<td>68 (29.2%)</td>
</tr>
<tr>
<td>V1: route/schedule</td>
<td>2189 (99.9%)</td>
<td>174 (94.5%)</td>
</tr>
<tr>
<td>V2: itinerary</td>
<td>2 (0.1%)</td>
<td>10 (5.5%)</td>
</tr>
<tr>
<td>V1: okay/correct</td>
<td>1371 (49.3%)</td>
<td>48 (27.7%)</td>
</tr>
<tr>
<td>V2: right</td>
<td>1409 (50.7%)</td>
<td>125 (72.3%)</td>
</tr>
<tr>
<td>V1: help</td>
<td>2189 (99.9%)</td>
<td>17 (65.3%)</td>
</tr>
<tr>
<td>V2: assistance</td>
<td>1 (0.1%)</td>
<td>9 (34.7%)</td>
</tr>
<tr>
<td>V1: query</td>
<td>6256 (99.9%)</td>
<td>70 (20.4%)</td>
</tr>
<tr>
<td>V2: request</td>
<td>3 (0.1%)</td>
<td>272 (79.6%)</td>
</tr>
</tbody>
</table>

D1 = V1 was in system prompts
D2 = V2 was in system prompts
(frequencies in user utterances)
Politeness

- Dialogue as social interaction – follows social conventions

- indirect is polite
  - this is the point of most indirect speech acts
  - clashes with conversational maxims (m. of manner)
  - appropriate level of politeness might be hard to find
    - culturally dependent

- face-saving (Brown & Lewinson)
  - positive face = desire to be accepted, liked
  - negative face = desire to act freely
  - face-threatening acts – potentially any utterance
    - threatening other’s/own negative/positive face
  - politeness softens FTAs

<table>
<thead>
<tr>
<th>threat to</th>
<th>positive face</th>
<th>negative face</th>
</tr>
</thead>
<tbody>
<tr>
<td>self</td>
<td>apology, self-humiliation</td>
<td>accepting order / advice, thanks</td>
</tr>
<tr>
<td>other</td>
<td>criticism, blaming</td>
<td>order, advice, suggestion, warning</td>
</tr>
</tbody>
</table>

Open the window.
Can you open the window?
Would you be so kind as to open the window?
Would you mind closing the window?
Politeness in dialogue systems

- Typically **handcrafted** by system design
  - does not adapt to situation very much
  - typically not much indirect speech, but trying to stay polite

- Learning from data can be tricky
  - **check your data** for offensive speech!
  - not just swearwords – problems can be hard to find

---

I already have a woman to sleep with.

(Experimental chatbot we trained at Heriot-Watt using Reddit data)
Summary

• Dialogue is messy
  • *turn* overlaps, *barge-ins*, weird grammar […]

• Dialogue utterances are acts
  • *illocution* = pragmatic meaning

• Dialogue needs understanding
  • *grounding* = mutual understanding management
    • *backchannels*, *confirmations*, *clarification*, *repairs*

• Dialogue takes place in context
  • lot of pointing – *deixis*

• Dialogue is cooperative, social process
  • *conversational maxims* ~ “play nice”
  • all while following *social conventions* (politeness)
  • people *predict & adapt* to each other

• Next week: where & how to get data, how to evaluate dialogue systems
Thanks

Contact me: odusek@ufal.mff.cuni.cz
room 424 (but email me first)

Get the slides here: http://ufal.cz/npfl123

References/Inspiration/Further:
Apart from materials referred directly, these slides are based on:

• Pierre Lison’s slides (Oslo University): https://www.uio.no/studier/emner/matnat/ifi/INF5820/h14/timeplan/index.html
• Ralf Klabunde’s lectures and slides (Ruhr-Universität Bochum): https://www.linguistics.ruhr-uni-bochum.de/~klabunde/lehre.htm
• Arash Eshghi & Oliver Lemon’s slides (Hériot-Watt University): https://sites.google.com/site/olemon/conversational-agents
• Gina-Anne Levow's slides (University of Washington): https://courses.washington.edu/ling575/
• Eika Razi’s slides: https://www.slideshare.net/eikarazi/anaphora-and-deixis
• Wikipedia: Anaphora (linguistics) Conversation Cooperative_principle Coreference Deixis Grounding_in_communication Implicature Speech_act Sprechakttheorie

Labs tomorrow
9:00 SU1

Talk to me about
Ph.D./MSc./BSc. theses!