Lecture 11: Dialog Systems

LTAT.01.001 – Natural Language Processing
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Dialog systems or conversational systems

• Phone-based personal assistants
  • SIRI, Alexa, Cortana, Google Assistant
• Talking to your car
• Communicating with robots
• Clinical uses for mental health
• Chatting for fun
Two-classes of systems

1. Chatbots

2. (Goal-based) dialog agents
   • Siri, interfaces to cars, robots
   • booking flights or restaurants
Chatbots
Chatbots

• Systems designed for extended dialogues
• Attempt to mimic the unstructured conversations or chats
• Originally designed as a testbed for clinical therapy
• Sometimes for fun
Chatbots

- ELIZA (1966)
- PARRY (1968)
  - The first system to pass Turing test
- ALICE
- CLEVER
- Microsoft Little Bing
Chatbot architectures

• Rule-based
  • Pattern-action rules (ELIZA)
  • +mental model (PARRY)

• Corpus-based
  • Information retrieval
  • Neural sequence-to-sequence models
Men are all alike.
IN WHAT WAY
They’re always bugging us about something or other.
CAN YOU THINK OF A SPECIFIC EXAMPLE
Well my boyfriend made me come here.
YOUR BOYFRIEND MADE YOU COME HERE
He says I’m depressed much of the time.
I AM SORRY TO HEAR YOU ARE DEPRESSED
WHO ELSE IN YOUR FAMILY TAKES CARE OF YOU?
My father
YOUR FATHER
You are like my father in some ways.
WHAT RESEMBLANCE DO YOU SEE
You are not very aggressive but I think you don’t want me to notice that.
WHAT MAKES YOU THINK I AM NOT AGGRESSIVE
You don’t argue with me.
WHY DO YOU THINK I DON’T ARGUE WITH YOU
You are afraid of me.
DOES IT PLEASE YOU TO BELIEVE I’M AFRAID OF YOU
My father is afraid of everybody.
WHAT ELSE COMES TO MIND WHEN YOU THINK OF YOUR FATHER
Bullies.
DOES THAT HAVE ANYTHING TO DO WITH THE FACT THAT YOUR BOYFRIEND MADE YOU COME HERE
Eliza algorithm

• Eliza attempts to mimic a Rogerian psychotherapist
• The idea is to draw the patient out by reflecting patient’s statements back at them
• It is the type of conversation in which one can “assume the pose of knowing almost nothing of the real world”
Rogerian psychotherapist

- Patient: “I went for a long boat ride”
- Therapist: “Tell me about boats”

- The therapist does not assume that the patient does not know what a boat is
- The therapist assumes that the patient has some conversational goal
Eliza pattern/transform rules

(* you * me) --> (What makes you think I 3 you)
You hate me --> What makes you think I hate you

(1 *) --> (You say you 2)
I know everybody laughed at me -->
You say you know everybody laughed at you
Eliza algorithm

function ELIZA GENERATOR(user sentence) returns response

Find the word \( w \) in \( sentence \) that has the highest keyword rank
   if \( w \) exists
      Choose the highest ranked rule \( r \) for \( w \) that matches \( sentence \)
      \( response \leftarrow \) Apply the transform in \( r \) to \( sentence \)
      if \( w = \text{’my’} \)
         \( future \leftarrow \) Apply a transformation from the ‘memory’ rule list to \( sentence \)
         Push \( future \) onto memory stack
   else (no keyword applies)
      either
         \( response \leftarrow \) Apply the transform for the NONE keyword to \( sentence \)
      or
         \( response \leftarrow \) Pop the top response from the memory stack
return(response)
Eliza algorithm – keyword matching

- Keyword ranking
  - Everybody: 5
  - I: 0
- (I *) --> (You say you 2)
- (* everybody *) --> (Who in particular are you thinking of?)

- If no keyword matches
  - “Please go on”
  - “That’s very interesting”
  - “I see”
Eliza algorithm – memory trick

• When the word “my” is the highest ranked keyword:
  • select a random transform from the MEMORY list
  • Apply it to the sentence
  • Store it on the stack

(MEMORY MY
 (0 MY 0 = LETS DISCUSS FURTHER WHY YOUR 3)
 (0 MY 0 = EARLIER YOU SAID YOUR 3)
 (0 MY 0 = DOES THAT HAVE ANYTHING TO DO WITH THE FACT THAT YOUR 3

• Later, when no keyword matches, return the top of the memory stack
Other Eliza stuff

• Transforms are not reused in the same conversation
  • Whenever a transform related to a pattern is used
  • increment a counter for that rule
  • so that next time the next ranked transform is used

• Some basic transforms happen during input processing
  • I --> you
  • you --> I

• Rules can refer to classes of words:
  • Family = mother, father, brother, sister
  • NOUN = ...
Some implications

• People became deeply emotionally involved with the program

• Weizenbaum tells the story of his secretary who would ask Weizenbaum to leave the room when she talked with ELIZA

• When he suggested that he might want to store all the ELIZA conversations for later analysis, people immediately pointed out the privacy implication
  • Suggesting that they were having private conversations with ELIZA
PARRY (Colby et al., 1971)

- Same patter-response structure Eliza
- Was used to study schizophrenia
- Included a model of its own mental states about anger, fear and mistrust
  - “If anger level is high, respond with hostility”
- First system to pass Turing test in 1972
  - Psychiatrists could not distinguish interviews with PARRY from (transcribed) interviews of real paranoids
Parry’s persona

• 28 year old single man, post office clerk
• no siblings, lives alone
• sensitive about his physical appearance, his family, his religion, his education and the topic of sex.
• hobbies are movies, gambling and horseracing
• recently attacked a bookie, claiming the bookie did not pay off in a bet
• afterwards worried about possible underworld retaliation
• eager to tell his story to non-threatening listeners
Affect variables

• Fear and anger (ranging from 0-20)
• Mistrust (ranging from 0-15)
• Initial condition: all low

• After each user turn, if nothing malevolent in input
  • Anger drops by 1, Fear drops by 0.3
  • Mistrust drops by 0.05

• Otherwise depends on what the user says
  • Each user statement can change Anger and Fear
  • Insults increase Anger by some percentage
  • Mistrust goes up if Anger or Fear do
ELIZA vs PARRY

ELIZA: Good Evening. Tell me your problems. Please terminate input with a period or a question mark.

PARRY: People get on my nerves sometimes.

ELIZA: I am not sure I understand you fully.

PARRY: You should pay more attention.

ELIZA: Suppose you should pay more attention.

PARRY: You're entitled to your own opinion.

ELIZA: What makes you think I am entitled to my own opinion?

PARRY: It bothers me just to be around people in general.

ELIZA: Please go on.

PARRY: I went to the track at Bay Meadows a while back.

ELIZA: What does that suggest to you?

PARRY: I went to the races.

ELIZA: Would you like to discuss your nerves?

PARRY: I guess so.

ELIZA: What does that suggest to you?

PARRY: What are you getting at?

ELIZA: What answer would please you most?

PARRY: It's not a matter or like or dislike.

ELIZA: What else would you like to discuss?

PARRY: I am getting tired of answering the same questions over and over.

ELIZA: What resemblance do you see?

PARRY: Why do you need to know that?

ELIZA: What do you think?

PARRY: I don't understand your motives.

ELIZA: Why don't you understand my motives?

IR-based chatbots

• Mine conversations of human chats or human-machine chats
• Respond to user’s turn X by repeating some appropriate turn Y from a corpus of natural text

• Systems differ mainly in:
  • How they choose the corpus
  • How they choose the appropriate response from the corpus
Corpora

• Databases of human conversations
  • Twitter
• Movie dialogs
• Corpora of narrative (non-dialog) texts
• Wikipedia
• Turns that the humans have used to respond to the chatbot
Cleverbot

- www.cleverbot.com

User: Do you like Doctor Who?
Cleverbot: Yes, so funny.
User: What’s your favorite show?
Cleverbot: I don’t have one.
User: What’s your name?
Cleverbot: Jason I already told you.
User: No your real name.
Cleverbot: Stephanie IS my real name.
User: I thought it was Jason?
Cleverbot: How did you come to that conclusion.
User: Because you said so.
Cleverbot: I have to do my homework.
Cleverbot

• Two cleverbots talking in 2011:
• https://www.youtube.com/watch?v=WnzIbyTZsQY
Choosing the response

• Return the most similar turn

\[ r = \arg\max_{t \in C} \cos(q, t) \]

• Return the following turn to the most similar turn

\[ r = \text{response} \left( \arg\max_{t \in C} \cos(q, t) \right) \]

• q – query
• C – conversational corpus
• t – turn in C
Choosing the response

• q = “Do you like Doctor Who”
• t = “Do you like Doctor Strangelove”

• Return the most similar turn
  • r = “Do you like Doctor Strangelove”

• Return the response to the most similar turn
  • r = “Yes, so funny”
Neural chatbots

- Response generation is treated as a conditioned generation, given the user’s previous turn
- Train on:
  - movie dialogue databases
  - Twitter conversations
Neural seq2seq chatbots
Problems with vanilla seq2seq

• They tend to produce dull and repetitive responses like “I’m OK” or “I don’t know”
  • Encourage beam decoder to keep more diverse responses in the beam
• They are unable to model longer prior context of the conversation
  • Hierarchical encoder over words and utterances
• They tend to generate single responses which don’t cohere over multiple turns
  • Add reinforcement or adversarial goals
<table>
<thead>
<tr>
<th>Input</th>
<th>Vanilla-SEQ2SEQ</th>
<th>Adversarial</th>
</tr>
</thead>
<tbody>
<tr>
<td>tell me ... how long have you had this falling sickness?</td>
<td>i’m not a doctor.</td>
<td>a few months, i guess.</td>
</tr>
</tbody>
</table>

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<th>Vanilla-SEQ2SEQ</th>
<th>Adversarial</th>
</tr>
</thead>
<tbody>
<tr>
<td>so i had the doctors test sammy ’s response to conditioning .</td>
<td>sammy wrote the test sammy wrote the test .</td>
<td>so he took the pills .</td>
</tr>
</tbody>
</table>

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<th>Vanilla-SEQ2SEQ</th>
<th>Adversarial</th>
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</thead>
<tbody>
<tr>
<td>they didn ’t have much success with this problem commander .</td>
<td>they ’re not the only ones who have been in the system .</td>
<td>can we find someone else ?</td>
</tr>
</tbody>
</table>
Evaluating chatbots

• Human evaluation

• ADEM (Lowe et al., 2017) – a classifier trained on a set of responses labelled by humans to predict the appropriateness of a dialogue turn

• Adversarial evaluation – train a “Turing-like” evaluator classifier to distinguish between human- and machine-generated responses
Frame based dialogue systems
Siri 2014

“Find restaurants near me”
tap to edit

I found fifteen restaurants fairly close to you:

15 Restaurants

Emmy's Spaghetti Shack  0.2 mi >
18 Virginia Ave
Italian, $$$
★ ★ ★ ★ ★ 1101 Reviews

ICHI Sushi  0.2 mi >
3369 Mission St
Japanese, Sushi Bars, $$$
★ ★ ★ ★ ★ 260 Reviews

Avedano's Holly Park M...  0.2 mi >

“Are any of them Italian”
tap to edit

My web search turned this up:

Web Search
Are any of them Italian

any - Dizionario inglese-italiano
WordReference
www.wordreference.com
English-Italian Dictionary | any ... of any sort adj (of an unspecified variety) di qualsiasi

Italian language - Wikipedia, the free encyclopedia
en.wikipedia.org
Italian or lingua italiana) is a Romance
“Find restaurants near me”

I found fifteen restaurants fairly close to you:

15 Restaurants

Emmy's Spaghetti Shack 0.2 mi
18 Virginia Ave
Italian, $$$$
★★★★★ 1101 Reviews

ICHI Sushi 0.2 mi
3369 Mission St
Japanese, Sushi Bars, $$$$
★★★★★ 260 Reviews

Avedano's Holly Park M... 0.2 mi

“Tell me more about the second one”

I'm sorry, Dan, I'm afraid I can't do that.
“Find restaurants near me”

Here’s what I found:

15 Results
Nearby

Ichi Sushi & Ni Bar
Japanese · 800 feet · Closed now
★★★★★ (311) on Yelp · $$$

Coco’s Ramen
Vietnamese · 800 feet · Closed now
★★★★★ (280) on Yelp · $$$

Blue Plate
Restaurant · 0.2 miles · Closed now
★★★★★ (1251) on OpenTable · $$$

Jasmine Tea House
Chinese · 800 feet · Closed now

“Ichi Sushi & Ni Bar is a Japanese restaurant on Mission St 800 ft to your west. It averages 3½ stars and is somewhat pricey.”
Frame-based or task-based dialog systems

- Based on a **domain ontology** - a data structure that represents possible intentions extracted from the user’s sentences.
- Ontology defines a set of frames.
- Each frame consists of a set of slots.
- Each frame defines a set of values that each slot can take.
The Frame

- A set of slots, to be filled with information of a given type
- Each associated with a question to the user

<table>
<thead>
<tr>
<th>Slot</th>
<th>Type</th>
<th>Question</th>
</tr>
</thead>
<tbody>
<tr>
<td>ORIGIN</td>
<td>city</td>
<td>What city are you leaving from?</td>
</tr>
<tr>
<td>DESTINATION</td>
<td>city</td>
<td>Where are you going?</td>
</tr>
<tr>
<td>DEPARTURE DATE</td>
<td>date</td>
<td>What day would you like to leave?</td>
</tr>
<tr>
<td>DEPARTURE TIME</td>
<td>time</td>
<td>What time would you like to leave?</td>
</tr>
<tr>
<td>AIRLINE</td>
<td>line</td>
<td>What is your preferred airline?</td>
</tr>
</tbody>
</table>
GUS system for travel planning

- Bobrow et al., 1977. GUS, A Frame-Driven Dialog System
- Still the industrial state-of-the-art
- SIRI based on GUS architecture
GUS: Hello. My name is GUS. I can help you plan a simple trip by air. Where do you want to go?
Client: I want to go to San Diego on May 28
GUS: What time do you want to leave?
Client: I must be in San Diego before 10 am
GUS: Would you like P.S.A. flight 102 that arrives at 9.15 am?
Client: What is the next flight?
GUS: Air California flight 310 that leaves at 8.30am and arrives at 10.00am
Client: I’ll take the first one
GUS: In what name should I make a reservation, please?
Client: Dan Bobrow
GUS: I have confirmed the following flight:
Client: P.S.A. flight 102 on Wednesday May 28 from San Jose to San Diego that leaves at 7.30 am and arrives at 9.15 am.
GUS: What date do you want to return on?
Client: On Friday in the evening.
GUS: Would you like the flight that leaves at 7.45 pm?
Client: That’s fine.
GUS: I have confirmed the following flight: P.S.A. flight 307 on Friday May 30 from San Diego to San Jose that leaves at 7.45 pm and arrives at 9.30 pm. Thank you for calling. Goodbye.
Finite-state dialog manager
Finite-state dialog managers

• System completely controls the conversation with the user
• It asks the user a series of questions
• The system ignores (or misinterprets) anything the user says that is not a direct answer to the system’s questions
Initiative of the dialog

• Initiative: who has control of conversation
• In human conversations initiative shifts forth and back
• Systems that fully control the initiative are called system-initiative
  • They typically also allow universal commands such as help and start over
• Systems that allow more flexibility are called mixed-initiative
  • The system must be able to understand switches between frames
  • The system must be able to understand which slots of which frames can be filled from the user’s utterance
• The GUS system is mixed-initiative
The frames are mixed initiative

• System asks questions from the user, filling any slots the user specifies
• When frame is filled, do database query
• For example, if user answers 3 questions at once, system can fill 3 slots and does not have to ask these questions again
Extracting information from user’s input

1. Domain classification
   • Asking weather?
   • Booking a flight?
   • Programming alarm clock?

2. Intent determination
   • Find a movie
   • Show flight
   • Remove Calendar App

3. Slot filling
   • Extract the actual slots and Fillers
Extracting information from user’s input

Show me morning flights from Boston to San Francisco on Tuesday

- **DOMAIN:** AIR-TRAVEL
- **INTENT:** SHOW-FLIGHTS
- **ORIGIN-CITY:** Boston
- **ORIGIN-DATE:** Tuesday
- **ORIGIN-TIME:** morning
- **DEST-CITY:** San Francisco
Slot filling

• Hand-written rules

Wake me tomorrow at 6

wake me (up) | set (the|an) alarm | get me up

INTENT: SET-ALARM
Slot filling

- Hand-written rules
- Semantic grammars

<table>
<thead>
<tr>
<th>Slot</th>
<th>Example Values</th>
</tr>
</thead>
<tbody>
<tr>
<td>SHOW</td>
<td>show me, i want, can i see...</td>
</tr>
<tr>
<td>DEPART_TIME_RANGE</td>
<td>(after</td>
</tr>
<tr>
<td>HOUR</td>
<td>one</td>
</tr>
<tr>
<td>FLIGHTS</td>
<td>(a) flight</td>
</tr>
<tr>
<td>AMPM</td>
<td>am</td>
</tr>
<tr>
<td>ORIGIN</td>
<td>from CITY</td>
</tr>
<tr>
<td>DESTINATION</td>
<td>to CITY</td>
</tr>
<tr>
<td>CITY</td>
<td>Boston</td>
</tr>
</tbody>
</table>
Slot filling

- Hand-written rules
- Semantic grammars

Diagram:

```
S
```
```
SHOW  FLIGHTS  ORIGIN  DESTINATION  DEPARTDATE  DEPARTTIME
```
```
Show  me  flights  from  Boston  to  San  Francisco  on  Tuesday  morning
```
Slot filling

• Hand-written rules
• Semantic grammars
• Supervised classifiers
  • classifiers for intent and domain
  • presence for a slot
  • IOB taggers
  • LSTM-IOB taggers
Evaluation

• Slot error rate

Slot Error Rate for a Sentence = \frac{\text{# of inserted/deleted/substituted slots}}{\text{# of total reference slots for sentence}}

Make an appointment with Chris at 10:30 in Gates 104

<table>
<thead>
<tr>
<th>Slot</th>
<th>Filler</th>
</tr>
</thead>
<tbody>
<tr>
<td>PERSON</td>
<td>Chris</td>
</tr>
<tr>
<td>TIME</td>
<td>11:30 a.m.</td>
</tr>
<tr>
<td>ROOM</td>
<td>Gates 104</td>
</tr>
</tbody>
</table>

SER = 1/3
Evaluation

• Slot error rate
• Slot precision/recall/F-score
• Task error rate
• Human satisfaction
Dialog system design

1. Study the user and task
2. Build simulations and prototypes: Wizard-of-Oz system
3. Iteratively test the design on users
Ethical issues in dialog system design

• AI and machine learning systems tend to replicate biases present in the training data
  • Microsoft Tay chatbot in 2016 that was taken offline 16 hour after it went alive
  • offensive and hate speech

• Privacy
  • People may reveal private information to chatbots, which is subsequently used as training data

• Gender equality
  • gender biases in data
  • responses of chatbots to offensive or sexually harassing language
Thanks for attending!