Natural Language Processing

Budditha Hettige
Department of Computer Engineering
Conversational Agents and Chatbots
Conversational Agents

• Phone-based Personal Assistants
  – SIRI
  – Cortana
  – Google Now
• Talking to your car
• Communicating with robots
• Clinical uses for mental health
• Chatting for fun
  – CleverBot
  – ALICE
Two classes of systems

• Goal-based dialog agents
  – SIRI
  – interfaces to cars, robots,

• Chatbots
“Make an appointment for Tuesday”

What time is your appointment?

“215”

OK, I can create your meeting. Note that you already have an appointment at 2:15 pm. Shall I schedule it anyway?

“No”

To continue, you can Confirm, Cancel, Change the Time, or Change the Title.

OK. You’re probably way too busy anyway, Dan.
“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 →

“I’m sorry, Dan, I’m afraid I can’t do that.”
“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

Italian language - Wikipedia, the free encyclopedia
en.wikipedia.org

Italian or lingua italiana) is a Romance
Architectures

• Finite-State
  – Just for passwords or credit cards

• Rule-based

• Active Ontology/Frame Based
  – SIRI etc

• Hybrid
How SIRI works

Figure from Jerome Bellegarda
Finite-State Dialog Management

Consider a trivial airline travel system:

Ask the user for a departure city
Ask for a destination city
Ask for a time
Ask whether the trip is round-trip or not
Finite State Dialog Manager

1. What city are you leaving from?
2. Where are you going?
3. What date do you want to leave?
4. Is it a one-way trip?
   - Yes
     - Do you want to go from <FROM> to <TO> on <DATE>?
   - No
     - What date do you want to return?
       - Yes
         - Do you want to go from <FROM> to <TO> on <DATE> returning on <RETURN>?
       - No
         - Book the flight
Finite-state dialog managers

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

System completely controls the conversation

• 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)

• Too limited
Problems with System Initiative

• Real dialogue involves give and take!
• In travel planning, users might want to say something that is not the direct answer to the question.
• For example answering more than one question in a sentence:

Hi, I’d like to fly from Seattle Tuesday morning; I want a flight from Milwaukee to Orlando one way leaving after 5 p.m. on Wednesday.
Single initiative + universals

• We can give users a little more flexibility by adding **universals**: commands you can say anywhere
• As if we augmented every state of FSA with these
  Help
  Start over
  Correct
• This describes many implemented systems
• But still doesn’t allow user much flexibility
Mixed Initiative

- Conversational initiative can shift between system and user
- Simplest kind of mixed initiative: use the structure of the frame to guide dialogue

<table>
<thead>
<tr>
<th>Slot</th>
<th>Question</th>
</tr>
</thead>
<tbody>
<tr>
<td>ORIGIN</td>
<td>What city are you leaving from?</td>
</tr>
<tr>
<td>DEST</td>
<td>Where are you going?</td>
</tr>
<tr>
<td>DEPT DATE</td>
<td>What day would you like to leave?</td>
</tr>
<tr>
<td>DEPT TIME</td>
<td>What time would you like to leave?</td>
</tr>
<tr>
<td>AIRLINE</td>
<td>What is your preferred airline?</td>
</tr>
</tbody>
</table>
Frames are mixed-initiative

- User can answer multiple questions at once.
- System asks questions of user, filling any slots that user specifies
  - When frame is filled, do database query
- If user answers 3 questions at once, system has to fill slots and not ask these questions again!
  - Avoids strict constraints on order of the finite-state architecture.
There are many ways to represent the meaning of sentences.

For speech dialogue systems, most common is “Frame and slot semantics”.

NLP 2020
An example of a frame

Show me morning flights from Boston to SF on Tuesday.

SHOW:

FLIGHTS:
ORIGIN:
  CITY: Boston
  DATE: Tuesday
  TIME: morning
DEST:
  CITY: San Francisco
Semantics for a sentence

LIST   FLIGHTS   ORIGIN
Show me   flights       from Boston

DESTINATION   DEPARTDATE
 to San Francisco   on   Tuesday

DEPARTTIME
morning
The way SIRI does NLU: Condition-Action Rules

- Active Ontology: relational network of concepts
  - **data structures**: a **meeting** has
    - a date and time,
    - a location,
    - a topic
    - a list of attendees
  - **rule sets** that perform actions for concepts
    - the **date** concept turns string
      - *Monday at 2pm* into
    - **date object**
      \[ \text{date}(\text{DAY}, \text{MONTH}, \text{YEAR}, \text{HOURS}, \text{MINUTES}) \]
Rule sets

• Collections of **rules** consisting of:
  – condition
  – action

• When user input is processed, facts added to store and
  – rule conditions are evaluated
  – relevant actions executed
Meeting concept: if you don’t yet have a location, ask for a location
Improvements to the Rule-Based Approach

• Statistical classifiers to map words to semantic frame-fillers
• Given a set of labeled sentences
  – “I want to fly to San Francisco on Tuesday”
    • Destination: SF
    • Depart-date: Tuesday
  – Build a classifier to map from one to the author
• Requirements: Lots of labeled data
Applications
Cortana

• Cortana is the name for the intelligent personal assistant and knowledge navigator for Windows Mobile and Windows 10.
• Cortana was demonstrated for the first time at the Microsoft BUILD Developer Conference (April 2–4, 2014) in San Francisco.
• It is named after Cortana, a synthetic intelligence character in Microsoft’s Halo video game franchise.
Cortana is constructed from the cloned brain of Dr. Catherine Elizabeth Halsey, the creator of the SPARTAN Project.

- It is written in C# (C Sharp).
- Can be talked to or typed at, Responds in the same way as addressed.
- Cortana is region-specific, and adapts its voice to match the everyday language, culture and speech patterns of the country its user lives in.
Speech processing for Cortana

1. Voice Input
2. Bing Voice Recognition API
3. Compare voice command with command configuration file
4. Perform defined bash command
5. Bing voice output API
6. Voice Output
Advantages of Cortana

• Advantage of an IPA (Intelligent Personal Assistant) like Cortana

  - We can type out our commands.
  - She’s a virtual assistant that can learn about us.
  - She can track our packages and trips.
  - Cortana is a standalone app.
  - Cortana is always running in background
What is Google Assistant?

- Google Assistant is an artificial intelligence-powered virtual assistant developed by Google that is primarily available on mobile and smart home devices.
- Unlike the company's previous virtual assistant, Google Now, the Google Assistant can engage in two-way conversations.
- Google Assistant is working with DialogFlow or known as API.AI
What Google Assistant can do?

• It is able to search the Internet, schedule events and alarms, adjust hardware settings on the user's device, and show information from the user's Google account.

• Google has also announced that the Assistant will be able to identify objects and gather visual information through the device's camera, and support purchasing products and sending money.

• You can also use Google Assistant to control most of the phone settings found in the notification shade. Like to open Wi-Fi, torch, to control brightness etc.
Google Home devices

- Google Home is the company's direct competitor to the Amazon Echo.
- Google Home is essentially a Chromecast-enabled speaker that serves as a voice-controlled assistant.
- There are currently five devices currently available in the Google Home portfolio including the Google Home, Google Home Max, Google Home Mini, the Nest Hub and Nest Hub Max.
• **Wear OS**
  – Google Assistant is also available on wearables running Wear OS

• **Android TV**
  – Android TV also offers Google Assistant on a number of devices

• **Headphones and earbuds**
  – There's support for Google Assistant in many wireless headphones, too. Initially starting with the Bose QuietComfort 35 II and Google's own Pixel Buds
How Google Assistant works?

• Usually, People interact with Google Assistant through natural voice but keyboard input is also possible. It similarly works as Google Now. It also uses the previous inputs to provide better answer in future.

• To use or activate google assistant:
  – In your android devices use the hot words “Ok Google” or “long press the home button”.
  – For “Google home” hands-free smart Speaker just say “Ok Google”.
  – In iPhone download the “Allo” app and then you can use Google Assistant in iPhone.
Dialogflow

• Google-owned developer of human–computer interaction technologies based on natural language conversations.

• The company is best known for creating the Assistant, a virtual buddy for Android, iOS, and Windows Phone smartphones that performs tasks and answers users' question in a natural language.

• Google bought the company in September 2016 and was initially known as API.AI; it provides tools to developers building apps ("Actions") for the Google Assistant virtual assistant. It was renamed on 10 October 2017 as Dialogflow.
Advantages

• Find Near Places.
  – Google’s assistant can also search for places near you

• Google Image Search.
  – If you want to see any image on Google, you just have to say Google Image in the mic on Google Assistants App. And Google Images will come in front of you.

• Find quick information.
  – With this help, you can find the temperature anywhere. or can it work as a lot/Currency conversion/Weather conditions/Opening any website/Changes in a unit of measurement/Translation, etc.

• Open Apps/Book Movie Tickets/Play Songs.
Disadvantages

• Will not work without a net.
  – Google Assistant will work only by connecting to the Internet.

• Hang on your mobile.
  – To run Google Assistant, your mobile must be the latest app for Google and the latest version of Google Assistants.

• Sinhala/Hindi not fully supported.
• Maximum battery use.
• High data use.
Alexa

• Amazon Alexa, simply known as Alexa is a virtual assistant developed by Amazon.

• First used in the Amazon Echo and the Amazon Echo Dot smart speakers developed by Amazon Lab126.

• Basically, Alexa is a voice-controlled Amazon assistant that turns words into actions.

• Alexa can also control several smart devices using itself as a home automation system.
Different Alexa Devices

- Amazon Echo
- Amazon Echo Plus
- Amazon Echo Dot
- Amazon Tap (Speaker)
- Amazon Echo Show
- Amazon Echo Spot
- Amazon Echo Look
- Amazon Fire TV Cube
How does Alexa Work?

• Most devices with Alexa allow users to activate the device using a wake-word such as Alexa.

• Other devices such as the Amazon mobile app on iOS or Androids require the user to push a button to activate Alexa’s listening mode.

• Currently, interaction and communications with Alexa are available only in English, German, French, Italian, Spanish, Japanese and Hindi.
Emotech : OLLY
What is OLLY?

• Olly is the first home robot with an evolving personality that adapts to each individual.
• Olly’s advanced machine learning technology proactively assists us with our day-to-day routine by remembering habits.
• Olly’s unique brain-inspired AI system – created by Emotech’s leading AI researchers and neuroscientists
Technology in OLLY

Two Smart Wide-angle Cameras
Olly detects facial expressions and body movements to make smart, proactive recommendations.

Innovative LED Lights & Movement
Olly creates a unique visual language by human movement simulation and color abstraction, to reflect moods, express emotion and convey personality.

Smart Speakers
Olly knows when to adjust the audio based on an understanding of the mood, scene and environment you are in.

Full Room Microphone Array
Olly uses four far-field microphones to receive accurate voice commands across the room.
How Olly Works?

- It uses camera sensors that can establish how many users are in a room at any given time. Once Olly is aware of who is present, it then adapts its responses to the user or group.

- If a user were to speak, the robot then used automatic speech recognition (ASR) to convert the users’ speech into text utterances. Natural Language Understanding (NLU) follows ASR and is how Olly learns each user’s preferences.
ChatBots
Chatbots

- **ELIZA (1966)**
- **PARRY (1968)**
  - The first system to pass the Turing test
- **ALICE**
- **CLEVER**
- **Microsoft XiaoIce 小冰**
- **Local Language ChatBots**
  - Sinhala
  - Other
Chatbot Architectures

- Rule-based
  - Pattern-action rules (Eliza)
  - + a mental model (Parry)
- Corpus-based (from large chat corpus)
  - Information Retrieval
  - Deep neural nets
- Hybrid
- Agent-based
ELIZA

- Created from 1964 to 1966 at the MIT Artificial Intelligence Laboratory by Joseph Weizenbaum
- ELIZA was not meant to be an AI system, it was meant to be a toy or a parody system
- ELIZA was first implemented in the SLIP language
- Created to demonstrate the superficiality of communication between humans and machines
- Use "pattern matching" and substitution methodology
Eliza is a mock Rogerian psychotherapist.
The original program was described by Joseph Weizenbaum in 1966.
This implementation by Norbert Landsteiner 2005.

ELIZA: Is something troubling you?
YOU: Men are all alike.
ELIZA: What is the connection, do you suppose?
YOU: They're always bugging us about something or other.
ELIZA: Can you think of a specific example?
YOU: Well, my boyfriend made me come here.
ELIZA: Is it important to you that your boyfriend made you come here?
YOU: He says I'm depressed much of the time.
ELIZA: I am sorry to hear that you are depressed.
YOU: It's true. I am unhappy.
ELIZA: Can you explain what made you unhappy?
YOU: [ ]
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
(0 YOU 0 ME) \[[\textit{pattern}]\]
\[\Rightarrow\]
(WHAT MAKES YOU THINK I 3 YOU) \[[\textit{transform}]\]

You hate me
WHAT MAKES YOU THINK I HATE YOU

0 means kleene \(^*\)
The 3 is the constituent \# in pattern
ELIZA architecture

• Examine each word \( w \) in user sentence
  – Return the \( w \) with highest keyword rank
• If \( w \) exists:
  – Check each rule for \( w \) in ranked order
    – Choose first one that matches sentence
    – Apply transform
• If no keyword applies, either
  • Apply the transform for the “NONE” key, or
  • Grab an action off the memory queue
Parry

- **PARRY** was an early example of a chatterbot, implemented in 1972
- Same pattern-response structure as Eliza
- But a much richer:
  - control structure
  - language understanding capabilities
  - mental model: Parry has affective variables
    - Anger, Fear, Mistrust
    - “If Anger level is high, respond with hostility”
- The first system to pass the Turing test (in 1971)
  - Psychiatrists couldn’t distinguish interviews with PARRY from interviews with real paranoids
- PARRY and ELIZA were hooked up over ARPANET and "talked" to each other
Parry’s persona

- 28-year-old single man, post office clerk
- no siblings and lives alone
- sensitive about his physical appearance, his family, his religion, his education and the topic of sex.
- hobbies are movies and gambling on 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.
Parry’s Architecture

OUTPUT STRATEGY SELECTOR

CONDITION:
- excessive fear
- excessive anger
- input contains initial mention of delusion-topic
- follow up to delusion-topic
- input contains reference to self in sensitive area
- input contains initial mention of flare concept
- input is question
- input is neutral statement

REACTION:
- escape
- hostility
- fear
- express delusions as long as value of variables low
- defensiveness
- anxiety
- answer
- normal reply

input

input strategies for detection of condition

modify affect variables

output
Affect variables

• Fear and Anger (each ranging 0-20)
• Mistrust (ranging 0-15)
• Initial conditions: 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 to base level

• Otherwise depends on what the user says
  – Each user statement can change Fear and Anger
    • Insults increases Anger by some percentage
  – Mistrust goes up if Fear or Anger do
Lots of complex I-O rules

- User implies Parry is mentally ill
  - Rise in Fear and Anger
- User mentions “Mafia” or associated concepts (“kill”):
  - First mention: rise in Fear
  - Later mentions: depends on willingness to discuss, which depends on current levels of Fear, Anger, Mistrust
- User mentions Parry
  - Flattery (positive mention)
    - decreases fear/anger if Mistrust is low
    - Increases Anger if Mistrust is high
  - User attitudes toward Parry
    - Negative attitudes (fear, disbelief) increase Fear/Anger
A Parry conversation

(1) How are you today?
   OK.
(2) What is your name?
   MY NAME IS FRANK SMITH.
(3) How old are you?
   TWENTY-EIGHT.
(4) Are you married?
   NO.
(5) What sort of work do you do?
   I WORK IN THE POST OFFICE.
(6) Why are you in the hospital?
   I SHOULDN’T BE HERE
(7) Who brought you here?
   THE POLICE

[FEAR rises slightly because police linked in graph to MAFIA]
Good Evening. Tell me your problems. Please terminate input with a period or a question mark.

*People get on my nerves sometimes. I am not sure I understand you fully.
*You should pay more attention.
Suppose you should pay more attention.
*You're entitled to your own opinion.
What makes you think I am entitled to my own opinion?

*It bothers me just to be around people in general. Please go on.
*I went to the track at Bay Meadows a while back. What does that suggest to you?
*I went to the races.
What else would you like to discuss?
Horseracing interests me.
Why do you say that just now?
There's a lot of crooked gambling going on there.
I am not sure I understand you fully,
It's clear to me if not to you.
Do you think it's likely that not to I?
I went to the races.
Please go on.
I gamble on horses.
What does that suggest to you?
I went to the races.
What else would you like to discuss?
Gambling has been nothing but trouble to me.
Why do you say that just now?
I've had experience with crooks gambling at the track.
I am not sure I understand you fully.
I've already told you enough about that.
IR-based models of chatbots

• Cleverbot
• Xiaoice
• Mine conversations of human chats or human-machine chats
• Choose a response by finding a prior turn that matches the user’s turn, and give the prior response to that turn.
Deep-learning chatbots

• Train on:
  – movie dialogue databases
  – twitter conversations

• Train a deep neural net to map from one user's turn to the other user's response
Seq2seq model architecture


Figure 1: The computational graph of the HRED architecture for a dialogue composed of three turns. Each utterance is encoded into... the model parameters, and helps propagate the training signal for first-order optimization methods (Sordoni et al. 2015a).
Sample outputs from a neural net chatbot

How are you doing?
I’m good, you?
I am off all week next week
What time you going?
I know you love me and I love you.
I love you too, baby.

Ohh I’ve never seen that! How long does it take you guys to learn the drill?
Like 2 weeks ago!!

Jiwei Li, Michel Galley, Chris Brockett, Jianfeng Gao, and Bill Dolan. 2015. A Diversity-Promoting Objective Function for Neural Conversation Models.
ALICE

• Artificial Linguistic Internet Computer Entity
• The program was rewritten in Java beginning in 1998
• Program uses an XML Schema called AIML
CleverBot

- Cleverbot's responses are not pre-programmed
- It learns from human input
Local Chatbot

NLP 2020
**Sinhala chatbot**

- Sinhala Morphological Analyzer
- Sinhala Parser
- Knowledge Identification Engine
- Sinhala Morphological Generator
- Sinhala Composer
- Lexical Dictionary
- Knowledge base
Octopus

- Core System
- GUI system
- Learning system
- Data access system
- NLP system
- Communication system
- Searching system
- Action system
- Ontology

Octopus: Multi Agent Chatbot (IRC 2015)
Octopus in Action

GUI System

Core System

Message Space

Learning system
Data access system
Natural Language Processing system
Communication system
Searching system
Action system

Octopus: Multi Agent Chatbot (IRC 2015)
Octopus in Action

Octopus: A multi-agent chatbot
version 1.0 (Beeta)
System Status: OK

Octopus Say...

User: එක අදිව?

Octopus: එක Octopus

User: එක නොක්ක වෙටින් මෙක්ක?

Octopus: එක වැදගත්තා මෙක්කක්?

User: එකව සොයා අදිවද අදිව?

Octopus: එකව අදිවද අදිව?

User: එකක අදිවද?

Octopus: එකව අදිවද?

User Say..
Available chatbot Builders

• Pandorabot
  – https://home.pandorabots.com/home.html

• DialogFlow
  – https://dialogflow.com/

• MobileMonkey
  – https://app.mobilemonkey.com/

• TARS
  – https://hellotars.com

• Etc.
Summary

• Commercial Systems:
  – Goal-oriented: ontology + hand-written rules for slot fillers
  – Non-goal-oriented:
    • Simple rule-based systems
    • IR-based: mine datasets of conversations.

• What’s the future
  – More use of data
    • Neural net models
    • IR-based models
  – Problems:
    • Acquiring that data
    • Integrating goal-based and chatbot-based systems
Thank you