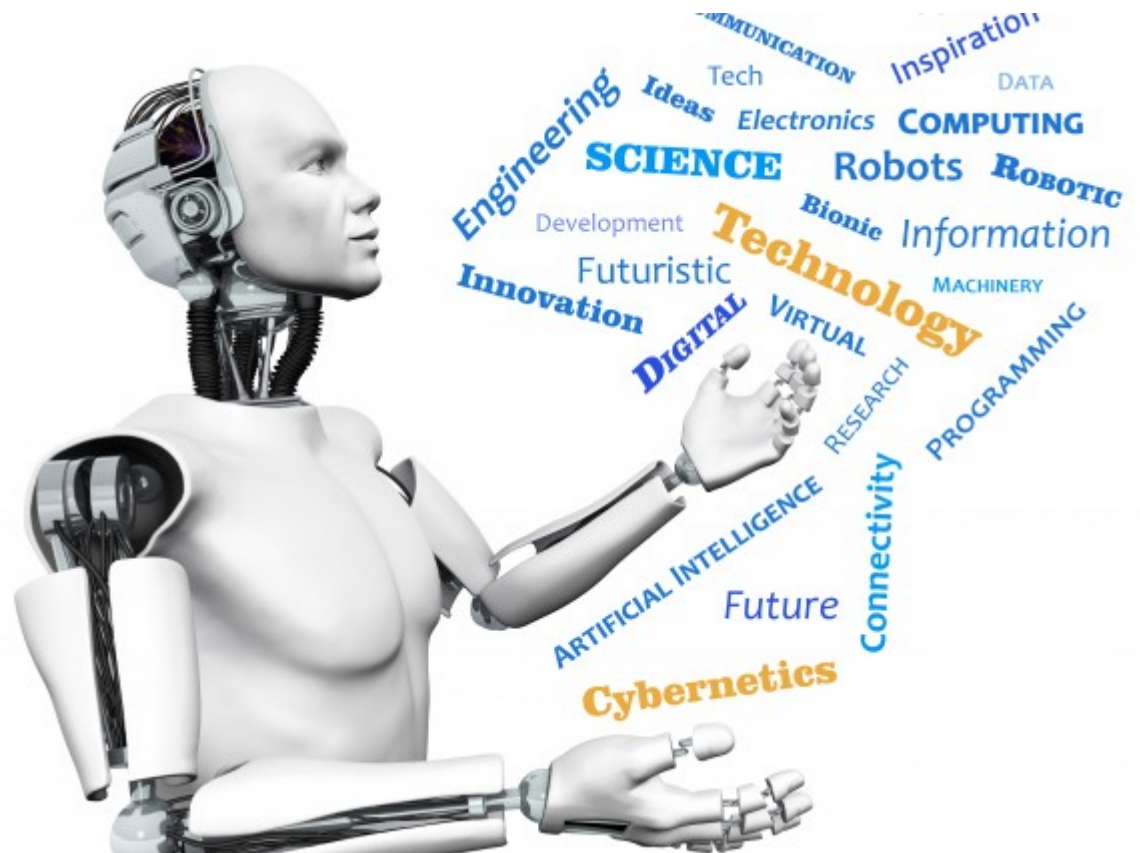


15-494/694: Cognitive Robotics

Dave Touretzky

Lecture 11:

Speech Generation and
Recognition



Speech Generation

- Cozmo does text-to-speech within the app
- Sends generated speech to the robot
- Parameters:
 - text
 - play_excited_animation [default False]
 - use_cozmo_voice [default True]
 - duration_scalar [default 1.0]
 - voice_pitch [-1.0 to 1.0]

“Say” Node

- Constant case:

```
Say('hello there') =C=> next
```

```
Say('greetings', duration_scalar=0.5)
```

- Event-driven case:

```
Compute() =SayData=> Say() =C=> next
```

- Subclassing “Say”:

```
class SpeakBattery(Say):
```

SpeakBattery

```
class SpeakBattery(Say):
    def start(self, event=None):
        self.text =
            'battery voltage %s' %
                robot.battery_voltage
        super().start(event)
```

Speech Recognition

- Cozmo has no microphone
- Use the laptop's mic or a USB mic
- Recognition via the Google Speech API
 - Must have network access to function.
 - Biased towards conversational English, not arbitrary robot commands.
- “Cozmo grab cube1” heard as:
 - “cozmo **crab** cube1”
- “Cozmo please grab cube1” heard as:
 - “cozmo please **grab** cube1”

Requesting Speech Recognition

Speech recognition is turned off by default.
To turn it on: use `speech=True` in
`StateMachineProgram`.

```
class CozmoCommand(StateMachineProgram):  
    def __init__(self):  
        super().__init__(speech=True,  
                          speech_debug=True)
```

When To Listen

- Microphone is always on
- Use a prefix to indicate we're addressing the robot, or a cube.
 - “Cozmo, grab a cube”
 - “Cube1, turn green”
- You've seen this trick before:
 - “Alexa, ...”
 - “Hey Siri, ...”
 - “OK Google, ...”

The =Hear()=> Transition

```
dispatch: Say('What now?')
```

```
dispatch =Hear('cozmo turn left')=>  
  Turn(90) =C=> dispatch
```

```
dispatch =Hear('cozmo drive forward')=>  
  Forward(50) =C=> dispatch
```


String Matching

- Convert everything to lowercase
- Remove all punctuation
- Normalize homophones

Homophones

- “Thesaurus” data structure defined in `cozmo_fsm/speech.py`
- Words:
 - `cozmo` ← `cosmo`, `cosmos`, `cosimo`, ...
 - `right` ← `write`, `wright`
 - `cube1` ← `q1`, `coupon`, `cuban`
- Phrases:
 - `cube1` ← `cube 1`
 - `paperclip` ← `paper clip`

Regular Expression Matching

- Uses the Python re package

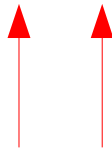
- Example: optional words

'cozmo ?(please|) drive forward'

- Be careful about spaces!

- Example: scanning for keywords:

'cozmo .* grab.*'



Checking the Match Results

- When a =Hear=> transition fires, it offers a SpeechEvent to the target node(s).
- The SpeechEvent contains three items:
 - **string:** the string that was matched
 - **words:** the list of words in string
 - **result:** the match result from re.match
 - contains the groups defined by ()

Extracting Groups (1)

```
from cozmo_fsm import *

class Speech1(StateMachineProgram):
    def __init__(self):
        super().__init__(speech=True,
                        speech_debug=True)

class Heard(Say):
    def start(self, event):
        obj = event.result.groups()[1]
        self.text = 'I will grab %s' % obj
        super().start(event)
```

Extracting Groups (2)

```
$setup{  
  loop: Say( 'what now' )  
  
  loop =Hear( 'cozmo ?(please|) grab  
    (cube1|cube2|cube3)' )=>  
    self.Heard() =C=> loop  
  
  loop =Hear=> Say( 'Pardon me?' )  
    =C=> loop  
}
```

Parsing

- We could write a parser for simple English commands and queries.
 - **Command:** “Cozmo, grab a cube”
 - **Command:** “Cozmo, find a door”
- This part is easy: each command directly translates to a state machine call.

Queries

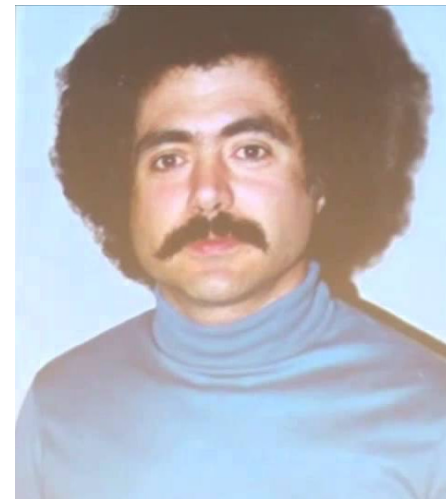
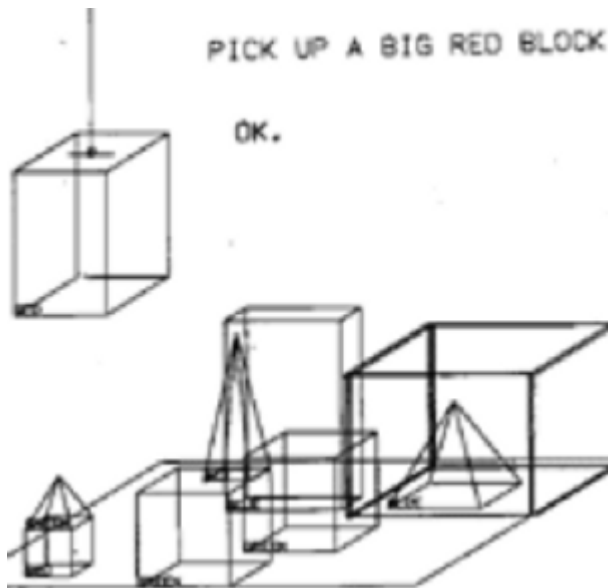
- Queries require access to a knowledge base and a mechanism for retrieval.
- What's in the knowledge base?
 - The world map
 - The robot's recent actions and plans
 - Recent object references
 - Necessary to resolve "it"

Dialog

- “Cozmo, are there any red cubes?”
- “Cozmo, did you touch any green **ones**?”
- “Cozmo, where is the nearest door?”
- Pronoun resolution:
 - “Cozmo, have you seen a blue cube?”
 - “Where is **it**?”

Terry Winograd's SHRDLU

- MIT PhD thesis, 1968–1970
- First natural language dialog system
- Robot arm in simulated blocks world.
- Teletype input, graphic display output.



<https://www.youtube.com/watch?v=bo4RvYJYOzI>

Sample SHRDLU Dialog

- What did the red cube support before you started to clean it off?
 - *The green pyramid.*
- There were five blocks to the left of the box then.
 - *No, only four of them: the red cube, two large green cubes and a large red block.*
- Put the blue pyramid on the block in the box.
 - *OK*

Natural Language Today: Winograd Schema Challenge

- Two sentences differ only in a verb.
Figure out the pronoun reference.
 - The city councilmen refused the demonstrators a permit because **they** [*feared / advocated*] violence.

