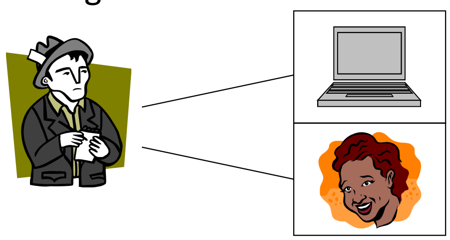
UNIT 13B
AI: Natural Language Processing

Announcement (1)

- Exam on Wednesday April 24
  - Covered topics: Randomness, Concurrency, Internet, Simulation, AI
    2:30 Exam: Sections A, B, C, D, E go to Rashid (GHC 4401) and Sections F, G go to PH 125C.
    3:30 Exam: Sections H, I, J, K, L, M, N all go to Rashid (GHC 4401).
    Bring your CMU id!
- Exam review at Sunday office hours (6-8pm) and (8-10pm).

The Turing Test

- Turing publishes Computing Machinery and Intelligence in 1950.
- Describes a test (now called the Turing Test) to determine whether a computer can be called intelligent.



A machine is considered intelligent if an interrogator cannot tell if a human or a computer is answering a set of questions using typewritten responses.

Turing's Prediction

- *"I believe that in about fifty years time it will be possible to program computers … to make them play the imitation game so well that an average interrogator will not have more than 70 percent chance of making the identification after five minutes of questioning."*

Natural Language Processing

- Natural language processing involves the interactions between a computer and a human via spoken (or written) language.
- ELIZA
  - One of the first programs to build a conversation between a human and a computer, created by Joseph Weizenbaum in 1966.
  - Computer responses were created based on *scripts*.
  - Most famous example was DOCTOR which simulated a Rogerian psychotherapist.

ELIZA in Popular Culture

- You can also repeatedly tell Siri "tell me a story." Eventually, she will tell you a story about how she was chosen to work for Apple Inc. and mentions ELIZA in the story. You can even ask about ELIZA to Siri and she will respond talking about ELIZA.

Source: Wikipedia

RubyLabs Eliza: A Sample Conversation

```
>> Eliza.run
How do you do. Please tell me your problem.
  H: I want a break from 15110.
  C: Why do you want a break from 15110?
  H: Because it takes a lot of time to do the homeworks.
  C: Is that the real reason?
  H: Maybe I discovered that I don't like computers so much.
  C: Do computers worry you?
  H: They worry me when I have to program them.
  C: You say 'They worry you when you have to program them'?
  H: Yes.
  C: You seem quite positive.
  H: Yes I am. Programming can be very tricky.
  C: Can you elaborate on that?
  H: You have to be very careful about everything.
  C: We were discussing you, not me.
  H: You got me wrong.
  C: Why do you think I got you?
  H: You did it again.
  C: Oh, I did it again?
```


ELIZA

H: My father wouldn't buy me a puppy.

C: Tell me more about your family.

H: I am sad I never got a puppy.

C: Can you explain what made you sad you never got a puppy?

H: I am sad we never had a chance to play fetch.

C: I am sorry to hear you are sad we never had a chance to play fetch.

Applying rules to Input Sentences

- Simplest type of rule: recognize keywords and reply with one of several predefined responses for that word.
- Then how to look for keywords?

Searching a String

```
>> s = “My dog ate the caterpillar.”
=> “My dog ate the caterpillar.”
>> s.include?(“dog”)
⇒ true
>> s.include?(“cat”)
=> true
>> s.include?(“Caterpillar”)
=> false
```

Regular Expressions

- A regular expression is a rule that describes the format required for a specific string.

```
>> s = “how now browner cow ow”
=> “how now browner cow ow”
>> r = /.ow/
=> /.ow/
```

r is a regular expression that says match any string consisting of 3 characters, where the first character is anything and the next 2 characters are ‘o’ and ‘w’ exactly

Iteration with a Regular Expression

- Scan scans through the string looking for anything that matches the regular expression passed to it.

```
>> s = “how now browner cow ow”
=> “how now browner cow ow”
>> r = /.ow/
=> /.ow/
>> s.scan(r)
=> [“how”, “now”, “row”, “cow”, “ ow”]
```

Examples

Syntax	Semantics
`.`	`Match any single character`
`.*`	`Match any number of characters`
`x	y	z`	`Match x or y or z`

Specific syntax and semantics may vary depending on the programming language, implementation, or library.

Regular Expressions in Practice

- Editors
  - Searching/replacing text
  - Syntax highlighting
- Query languages

RubyLabs: Pattern

include ElizaLab

- A sentence **`Pattern`** is a mapping from a regular expression to a set of 1 or more responses.
- Example:

creates a regular expression based on the first argument

```
>> p1 = Pattern.new("dog",
   ["Tell me more about your pet",
       "Go on"]
=> dog: ["Tell me more about your
pet", "Go on"]
```


More about Patterns

- The **`apply`** method tries to match an input sentence to a regular expression. If it can, it returns one of supplied response strings.

```
>> p1.apply("I love my dog.")
=> "Tell me more about your pet."
>> p1.apply("My dog is really smart.")
=> "Go on."
>> p1.apply("Much smarter than my cat.")
=> nil
```

```
p1 = Pattern.new("dog",
        ["Tell me more about your pet","Go on"]
)
```

Groups

- We can specify a **group** so that any member will cause a match during a scan.

```
>> p2 = Pattern.new("(cat|dog|bird)",
   ["Tell me more about your pet", "Go on"]
>> p2.apply("My dog is smelly.")
=> "Go on."
>> p2.apply("My cat ate my bird.")
=> "Tell me more about your pet."
>> p2.apply("I miss Polly a lot.")
=> nil
```


Placeholders

- We can extract part of the input sentence to use in the response.

```
>> p = Pattern.new("(cat|dog|bird)")
>> p.add_response("Tell me more about the $1")
>> p.add_response("A $1? Interesting.")
>> p.apply("A dog ate my homework.")
=> "Tell me more about the dog."
>> p.apply("My cat ate my bird.")
=> "A cat? Interesting."
```

Placeholders (cont'd)

```
>> p = Pattern.new("I (like|love|hate) my
  (cat|dog|bird)"
>> p.add_response("Why do you $1 your $2?")
>> p.add_response("Tell me more about your $2")
>> p.apply("I like my dog.")
=> "Why do you like your dog?"
>> p.apply("I hate my cat.")
=> "Tell me more about your cat."
```


Wildcards

- We can use a wildcard symbol (.*) to match any number of characters.

```
>> p = Pattern.new("I am afraid of (.*)")
>> p.add_response("Why are you afraid of $1?")
>> p.apply("I am afraid of ghosts")
=> "Why are you afraid of ghosts?"
>> p.apply("I am afraid of 15110")
=> "Why are you afraid of 15110?"
```

A Note About **`Pattern`**

- Pattern takes a string and converts it to a regular expression, adding some special characters.

```
>> p = Pattern.new("dog")
>> p.regexp              => /\bdog\b/i
>> p = Pattern.new("I like .*")
>> p.regexp              => /\bI like (.*)/i
>> p = Pattern.new(".eat")
>> p.regexp              => /.eat\b/i
```

\b word boundary
i ignore case

Postprocessing

- To make things more realistic, we can replace personal pronouns with their opposites.

```
>> p = Pattern.new("I am (.*)",
        ["Are you really $1?"])
>> p.apply("I am near my car")
=> "Are you really near my car?"
>> p.apply("I am annoyed at you")
=> "Are you really annoyed at you?"
```

Postprocessing (cont’d)

An associative array like we used in Huffman trees.

```
>> Eliza.post[“my”] = “your”
>> Eliza.post[“you”] = “me”
>> Eliza.post
=> {“my” => “your”, “you” => “me” }
>> p.apply(“I am near my car.”)
=> “Are you really near your car?”
>> p.apply(“I am annoyed at you.”)
=> “Are you really annoyed at me?”
>> p.apply(“I am sad, my my my.”)
=> "Are you really sad, your your your?"
```


Preprocessing

- Preprocessing is used to transform part of a sentence before pattern matching is performed.

```
>> p = Pattern.new(“I am afraid of (.*)”)
>> p.add_response(“Why are you afraid of $1?”)
>> p.apply(“I’m afraid of ghosts”)
=> nil
>> Eliza.pre[“I’m”] = “I am”
>> p.apply(“I’m afraid of ghosts”)
=> “Why are you afraid of ghosts?”
```

Algorithm for a Conversation

1. Perform any preprocessing on the sentence.
2. Break the sentence into words.
3. If there is a rule for a word, add the rule to a priority queue.
4. Try the rules in order of decreasing priority.
5. If a rule applies to the input sentence, apply postprocessing rules to placeholder variables and return the response.

Priority Queues (Reminder)

- A priority queue (PQ) is like an array that is sorted.
```
pq = PriorityQueue.new
=> []
```
- To add element into the priority queue in its correct position, we use the **<<** operator:
```
pq << "peach"
pq << "apple"
pq << "banana"
=> ["apple", "banana", "peach"]
```

Priority Queues (cont'd)

- To remove the first element from the priority queue, we will use the **`shift`** method:

```
fruit1 = pq.shift
=> "apple"
pq
=> ["banana", "peach"]
fruit2 = pq.shift
=> "banana"
pq
=> ["peach"]
```


Exercise

Try to build a conversation involving computers.

```
>> Eliza.rule_for("computer")
=>  [50] --> [
  /(computer|machine)s?/
    "Do $1s worry you?"
    "Why do you mention $1s?"
    "What do you think $1s have to do with your problem?"
    "Don't you think $1s can help people?"
    "What about $1s worries you?"
    "What do you think about $1s?"
]
```

Eliza and the Turing Test

- Human (natural) language is very complex.

  "You said I wouldn't be afraid of horses if I visited a state fair, but when I was there I was chased by a pig, and now I'm having nightmares about bacon."

  Natural language processors (NLPs) must use **parsers** to break a sentence down into its constituent parts (noun, verb, etc.) to determine an appropriate response.

Eliza and the Turing Test

- Human (natural) language is very complex.

  "The lions were lying down in the grass."
  A: Go on.

  "They were quiet"
  A: Why were the lions quiet?

  Natural language processors (NLPs) must have **memory** to associate words (e.g. "they") to words from previous sentences.

Eliza and the Turing Test

- Human (natural) language is very complex.

  "The elephant was huge."
  A: How big was it?

  "The cat fell into the well."
  A: Was it able to get out?

  NLPs must use **semantics** to assign meaning to certain phrases in order to generate appropriate responses.

Eliza and the Turing Test

- Human (natural) language is very complex.

  "The dog ran across the backyard while I waited on my patio."
  A: What happened when the dog reached the patio?

  NLPs must establish **inferences** to add information to sentences that is not given but is assumed.

Successful Chatbots

- **Cleverbot** by Rollo Carpenter.
- Since launching on the web in 1997, the number of conversations has exceeded 65 million.
- Cleverbot participated in a formal Turing Test in 2011. Out of the 334 votes cast, Cleverbot was judged to be 59.3% human.

Check out http://www.cleverbot.com/

Machile Learning

- Cleverbot learns from a growing database of 20+ million online conversations to talk with anyone who goes to its website.

Conclusions

- Predictions of Turing and others that natural language processing would be well-established by 2000 were optimistic.
- Some notable achievements: parsing, NLP interfaces such as in airline reservations, banks etc.
- Corpus linguistics and machine learning hold promise.

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