

ARTIFICIAL INTELLIGENCE: METHODS & APPLICATIONS

INTRODUCTION TO QUESTION ANSWERING AND CHAT BOTS

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February 1, 2018

Question Answering

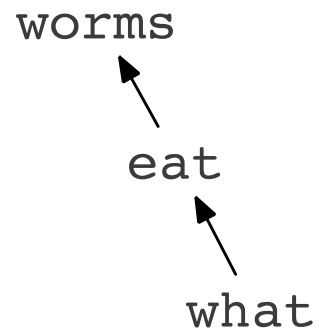
What is Question Answering

Question Answering

One of the oldest NLP tasks (punched card systems in 1961)

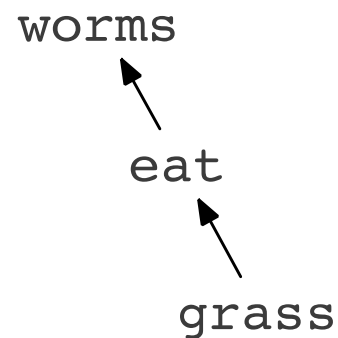
Question:

What do worms eat?

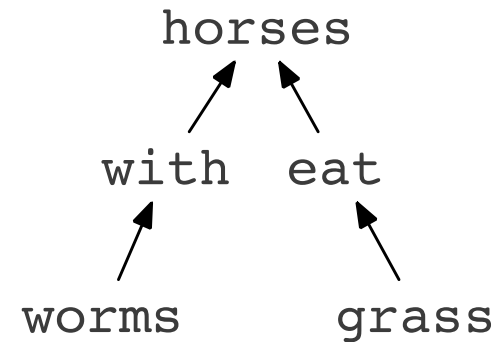


Potential Answers:

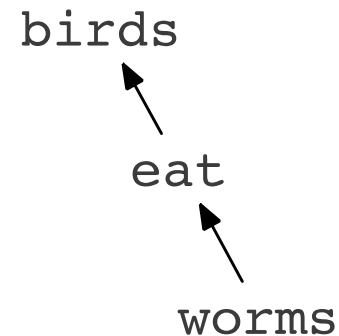
Worms eat grass



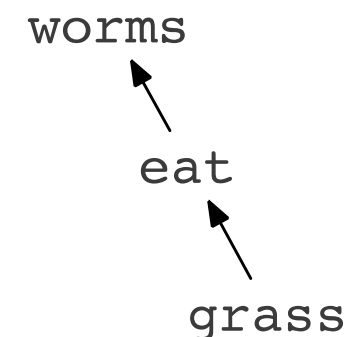
Horses with worms eat grass



Birds eat worms



Grass is eaten by worms



Simmons, Klein, McConlogue. 1964. Indexing and Dependency Logic for Answering English Questions. American Documentation 15:30, 196-204

Question Answering: IBM's Watson

- Won Jeopardy on February 16, 2011!

WILLIAM WILKINSON'S
"AN ACCOUNT OF THE PRINCIPALITIES OF
WALLACHIA AND MOLDOVIA"
INSPIRED THIS AUTHOR'S
MOST FAMOUS NOVEL



Bram Stoker

Apple's Siri



Wolfram Alpha



how many calories are in two slices of banana cream pie?



[Examples](#) [Random](#)

Assuming any type of pie, banana cream | Use [pie, banana cream, prepared from recipe](#) or [pie, banana cream, no-bake type, prepared from mix](#) instead

Input interpretation:

pie	amount	2 slices	total calories
	type	banana cream	

Average result:

[Show details](#)

702 Cal (dietary Calories)

Types of Questions in Modern Systems

- Factoid questions
 - *Who wrote “The Universal Declaration of Human Rights”?*
 - *How many calories are there in two slices of apple pie?*
 - *What is the average age of the onset of autism?*
 - *Where is Apple Computer based?*
- Complex (narrative) questions:
 - *In children with an acute febrile illness, what is the efficacy of acetaminophen in reducing fever?*
 - *What do scholars think about Jefferson’s position on dealing with pirates?*

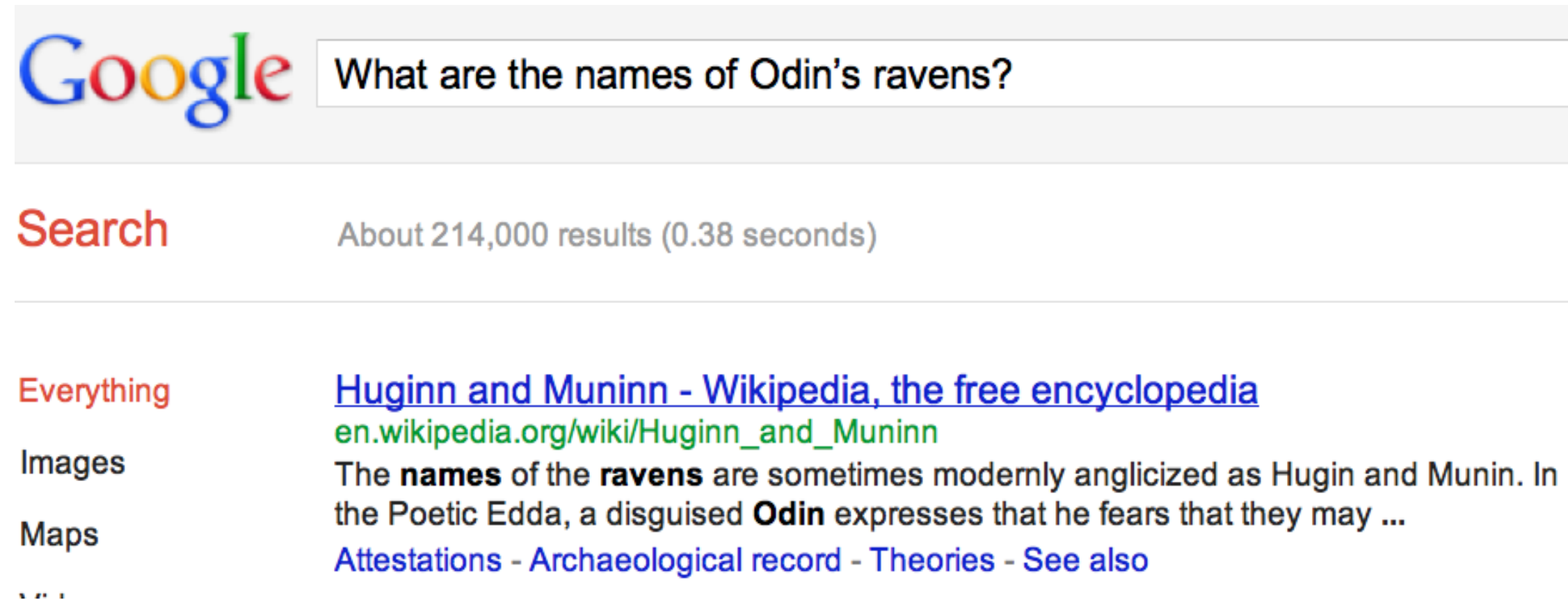
Commercial systems: mainly factoid questions

Where is the Louvre Museum located?	In Paris, France
What's the abbreviation for limited partnership?	L.P.
What are the names of Odin's ravens?	Huginn and Muninn
What currency is used in China?	The yuan
What kind of nuts are used in marzipan?	almonds
What instrument does Max Roach play?	drums
What is the telephone number for Stanford University?	650-723-2300

Paradigms for QA

- IR-based approaches
 - TREC; IBM Watson; Google
 - Text REtrieval Conference (TREC) <http://trec.nist.gov/>
 - http://trec.nist.gov/data/qa/t8_qadata.html
- Knowledge-based and Hybrid approaches
 - IBM Watson; Apple Siri; Wolfram Alpha; True Knowledge Evi

Many questions can already be answered by web search



The image is a screenshot of a Google search interface. At the top left is the Google logo. To its right is a search bar containing the text "What are the names of Odin's ravens?". Below the search bar, the word "Search" is on the left, and "About 214,000 results (0.38 seconds)" is on the right. A horizontal line separates the search bar area from the results area. On the left side of the results area, there are links for "Everything", "Images", "Maps", and "...". To the right of these links, the top result is for "Huginn and Muninn - Wikipedia, the free encyclopedia". The URL "en.wikipedia.org/wiki/Huginn_and_Muninn" is shown in green. Below the URL, a snippet of text reads: "The **names** of the **ravens** are sometimes modernly anglicized as Hugin and Munin. In the Poetic Edda, a disguised **Odin** expresses that he fears that they may ...". At the bottom of the snippet, there are blue links: "Attestations - Archaeological record - Theories - See also".

Google

What are the names of Odin's ravens?

Search About 214,000 results (0.38 seconds)


Everything [Huginn and Muninn - Wikipedia, the free encyclopedia](#)
en.wikipedia.org/wiki/Huginn_and_Muninn
The **names** of the **ravens** are sometimes modernly anglicized as Hugin and Munin. In the Poetic Edda, a disguised **Odin** expresses that he fears that they may ...
[Attestations](#) - [Archaeological record](#) - [Theories](#) - [See also](#)

Images

Maps

...

IR-based Question Answering



Where is the Louvre Museum located?

Search

About 904,000 results (0.30 seconds)

Everything

Images

Maps

Videos

News

Best guess for Louvre Museum Location is **Paris, France**

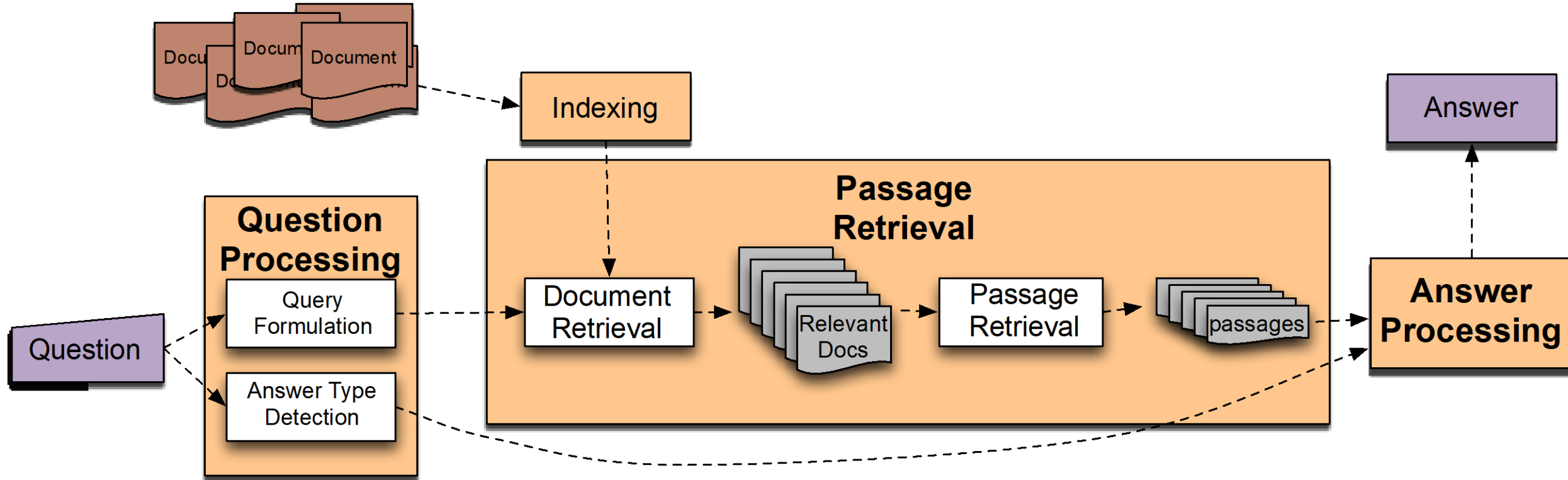
Mentioned on at least 7 websites including [wikipedia.org](#), [answers.com](#) and [east-buc.k12.ia.us](#) - [Show sources](#) - [Feedback](#)

[Musée du Louvre - Wikipedia, the free encyclopedia](#)
[en.wikipedia.org/wiki/Musée_du_Louvre](#)

Musée du **Louvre** is **located** in Paris. **Location** within Paris. Established, 1793. **Location**, **Palais Royal**, Musée du **Louvre**, **75001 Paris, France**. Type, Art **museum** ...

[Louvre Palace - List of works in the Louvre - Category:Musée du Louvre](#)

IR-based Factoid QA



IR-based Factoid QA

- QUESTION PROCESSING
 - Detect question type, answer type, focus, relations
 - Formulate queries to send to a search engine
- PASSAGE RETRIEVAL
 - Retrieve ranked documents
 - Break into suitable passages and rerank
- ANSWER PROCESSING
 - Extract candidate answers
 - Rank candidates
 - using evidence from the text and external sources

Knowledge-based approaches (Siri)

- Build a semantic representation of the query
 - Times, dates, locations, entities, numeric quantities
- Map from this semantics to query structured data or resources
 - Geospatial databases
 - Ontologies (Wikipedia infoboxes, dbPedia, WordNet, Yago)
 - Restaurant review sources and reservation services
 - Scientific databases

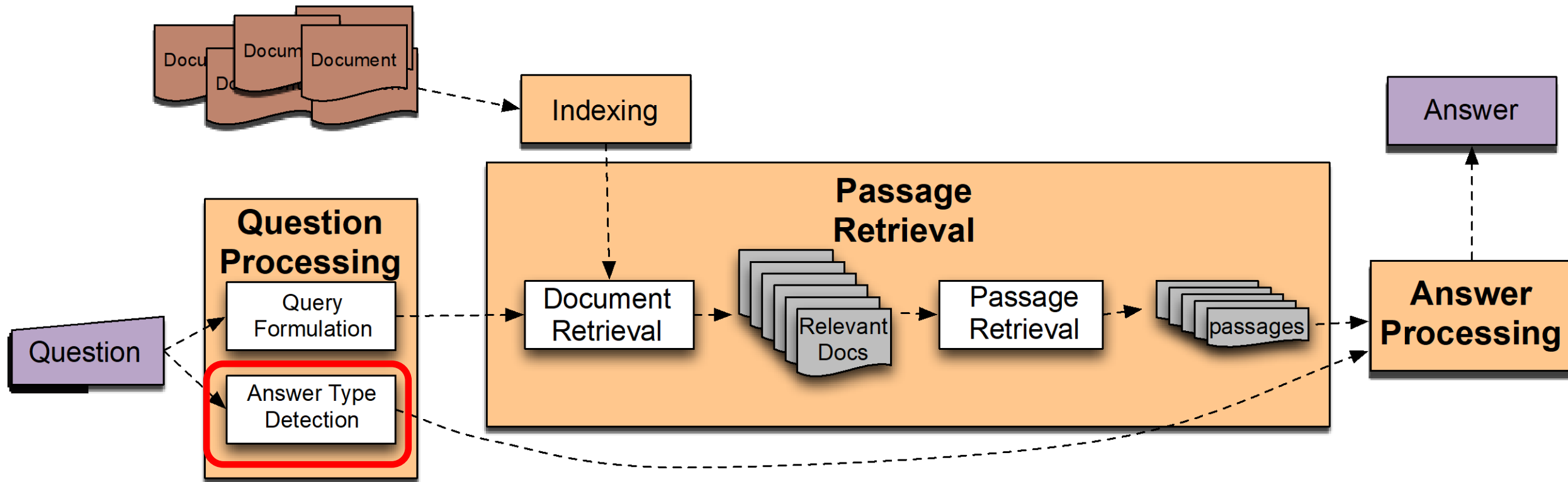
Hybrid approaches (IBM Watson)

- Build a shallow semantic representation of the query
- Generate answer candidates using IR methods
 - Augmented with ontologies and semi-structured data
- Score each candidate using richer knowledge sources
 - Geospatial databases
 - Temporal reasoning
 - Taxonomical classification

Question Answering

Answer Types and Query Formulation

Factoid Q/A



Question Processing: Things to extract from the question

- Answer Type Detection
 - Decide the **named entity type** (person, place) of the answer
- Query Formulation
 - Choose **query keywords** for the IR system
- Question Type classification
 - Is this a definition question, a math question, a list question?
- Focus Detection
 - Find the question words that are replaced by the answer
- Relation Extraction
 - Find relations between entities in the question

Question Processing

They're the two states you could be reentering if you're crossing Florida's northern border

- Answer Type: US state
- Query: two states, border, Florida, north
- Focus: the two states
- Relations: borders(Florida, ?x, north)

Answer Type Detection: Named Entities

- *Who founded Virgin Airlines?*
 - PERSON
- *What Canadian city has the largest population?*
 - CITY.

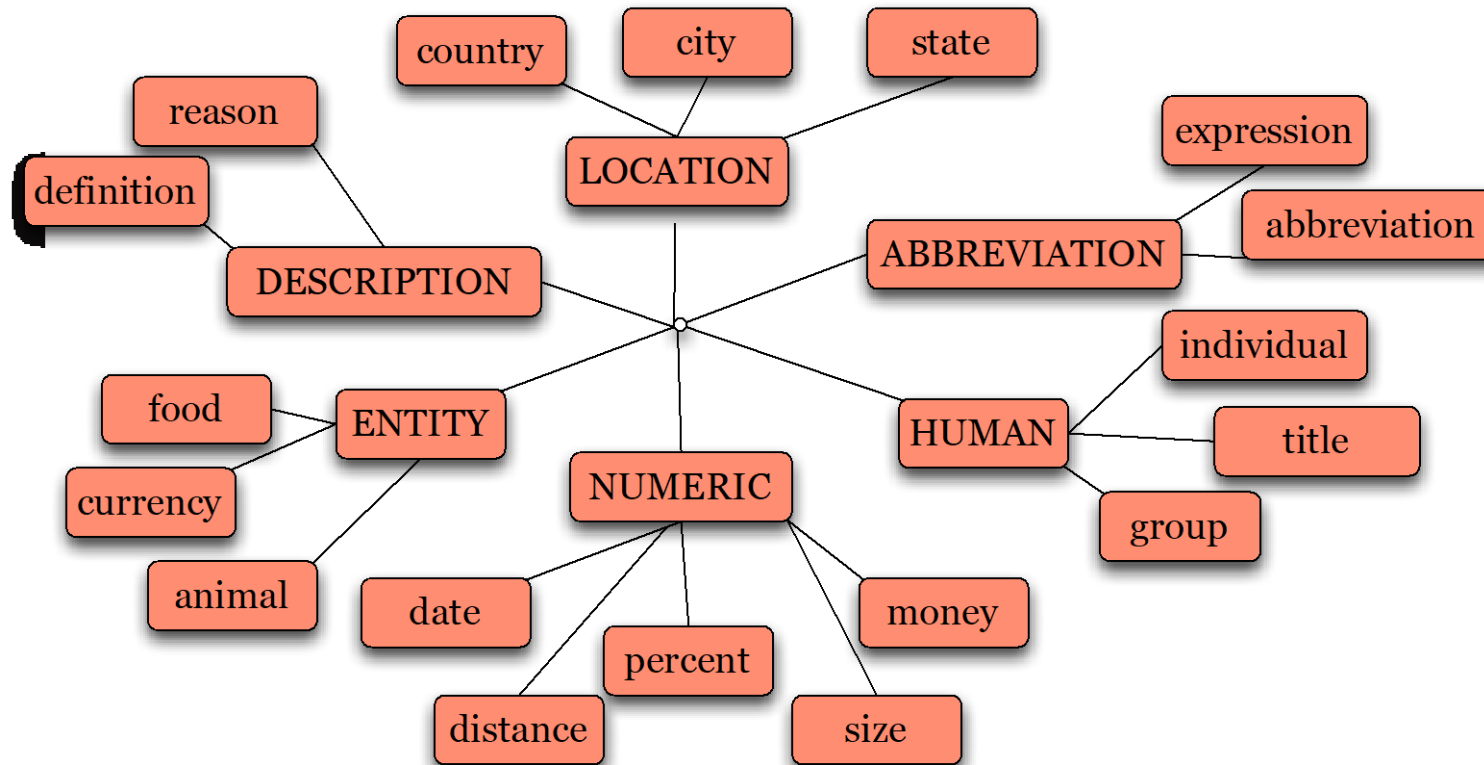
Answer Type Taxonomy

Xin Li, Dan Roth. 2002. Learning Question Classifiers. COLING'02
<http://cogcomp.cs.illinois.edu/papers/LiRo05a.pdf>

- 6 coarse classes
 - ABBEVIATION, ENTITY, DESCRIPTION, HUMAN, LOCATION, NUMERIC
- 50 finer classes
 - LOCATION: city, country, mountain...
 - HUMAN: group, individual, title, description
 - ENTITY: animal, body, color, currency...

Answer Type Taxonomy

Part of Li & Roth's Answer Type Taxonomy



Answer Types

ENTITY	
animal	What are the names of Odin's ravens?
body	What part of your body contains the corpus callosum?
color	What colors make up a rainbow ?
creative	In what book can I find the story of Aladdin?
currency	What currency is used in China?
disease/medicine	What does Salk vaccine prevent?
event	What war involved the battle of Chapultepec?
food	What kind of nuts are used in marzipan?
instrument	What instrument does Max Roach play?
lang	What's the official language of Algeria?
letter	What letter appears on the cold-water tap in Spain?
other	What is the name of King Arthur's sword?
plant	What are some fragrant white climbing roses?
product	What is the fastest computer?
religion	What religion has the most members?
sport	What was the name of the ball game played by the Mayans?
substance	What fuel do airplanes use?
symbol	What is the chemical symbol for nitrogen?
technique	What is the best way to remove wallpaper?
term	How do you say " Grandma " in Irish?
vehicle	What was the name of Captain Bligh's ship?
word	What's the singular of dice?

More Answer Types

HUMAN	
description	Who was Confucius?
group	What are the major companies that are part of Dow Jones?
ind	Who was the first Russian astronaut to do a spacewalk?
title	What was Queen Victoria's title regarding India?
LOCATION	
city	What's the oldest capital city in the Americas?
country	What country borders the most others?
mountain	What is the highest peak in Africa?
other	What river runs through Liverpool?
state	What states do not have state income tax?
NUMERIC	
code	What is the telephone number for the University of Colorado?
count	About how many soldiers died in World War II?
date	What is the date of Boxing Day?
distance	How long was Mao's 1930s Long March?
money	How much did a McDonald's hamburger cost in 1963?
order	Where does Shanghai rank among world cities in population?
other	What is the population of Mexico?
period	What was the average life expectancy during the Stone Age?
percent	What fraction of a beaver's life is spent swimming?
speed	What is the speed of the Mississippi River?
temp	How fast must a spacecraft travel to escape Earth's gravity?
size	What is the size of Argentina?
weight	How many pounds are there in a stone?

Answer types in Jeopardy

Ferrucci et al. 2010. Building Watson: An Overview of the DeepQA Project. AI Magazine. Fall 2010. 59-79.

- 2500 answer types in 20,000 Jeopardy question sample
- The most frequent 200 answer types cover < 50% of data
- The 40 most frequent Jeopardy answer types
he, country, city, man, film, state, she, author, group, here, company,
president, capital, star, novel, character, woman, river, island, king,
song, part, series, sport, singer, actor, play, team, show,
actress, animal, presidential, composer, musical, nation,
book, title, leader, game

Answer Type Detection

- Hand-written rules
- Machine Learning
- Hybrids

Answer Type Detection

- Regular expression-based rules can get some cases:
 - Who {is|was|are|were} PERSON
 - PERSON (YEAR – YEAR)
- Other rules use the **question headword**:
(the headword of the first noun phrase after the wh-word)
 - Which **city** in China has the largest number of foreign financial companies?
 - What is the state **flower** of California?

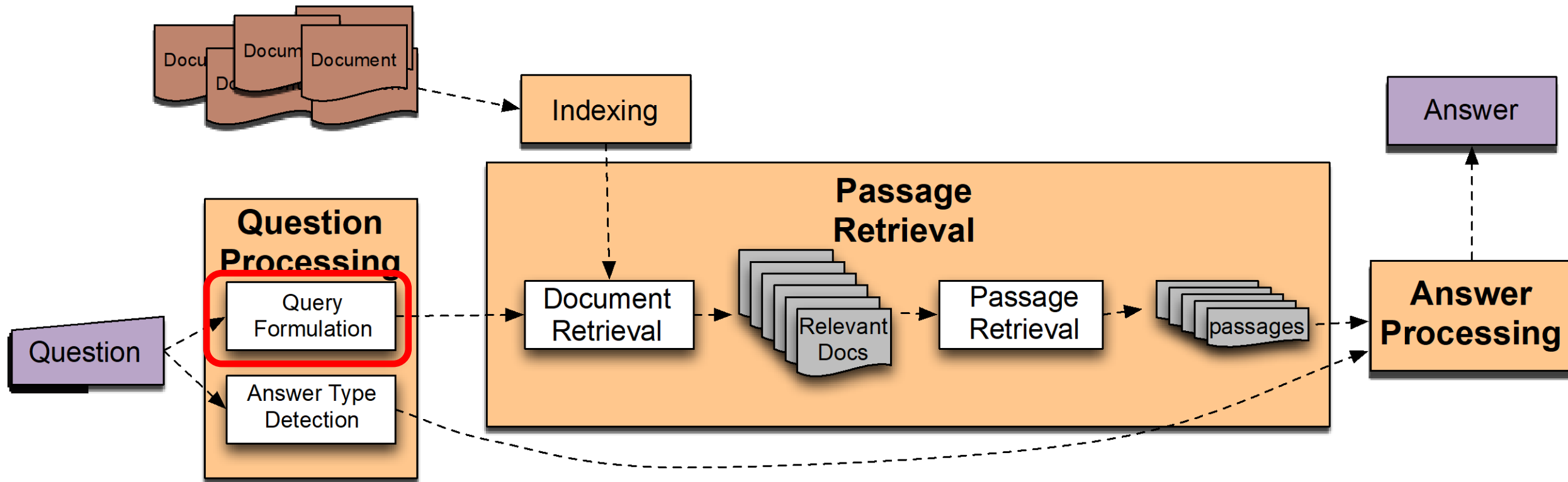
Answer Type Detection

- Most often, we treat the problem as machine learning classification
 - **Define** a taxonomy of question types
 - **Annotate** training data for each question type
 - **Train** classifiers for each question class using a rich set of features.
 - ✓ features include those hand-written rules!

Features for Answer Type Detection

- Question words and phrases
- Part-of-speech tags
- Parse features (headwords)
- Named Entities
- Semantically related words

Factoid Q/A



Keyword Selection Algorithm

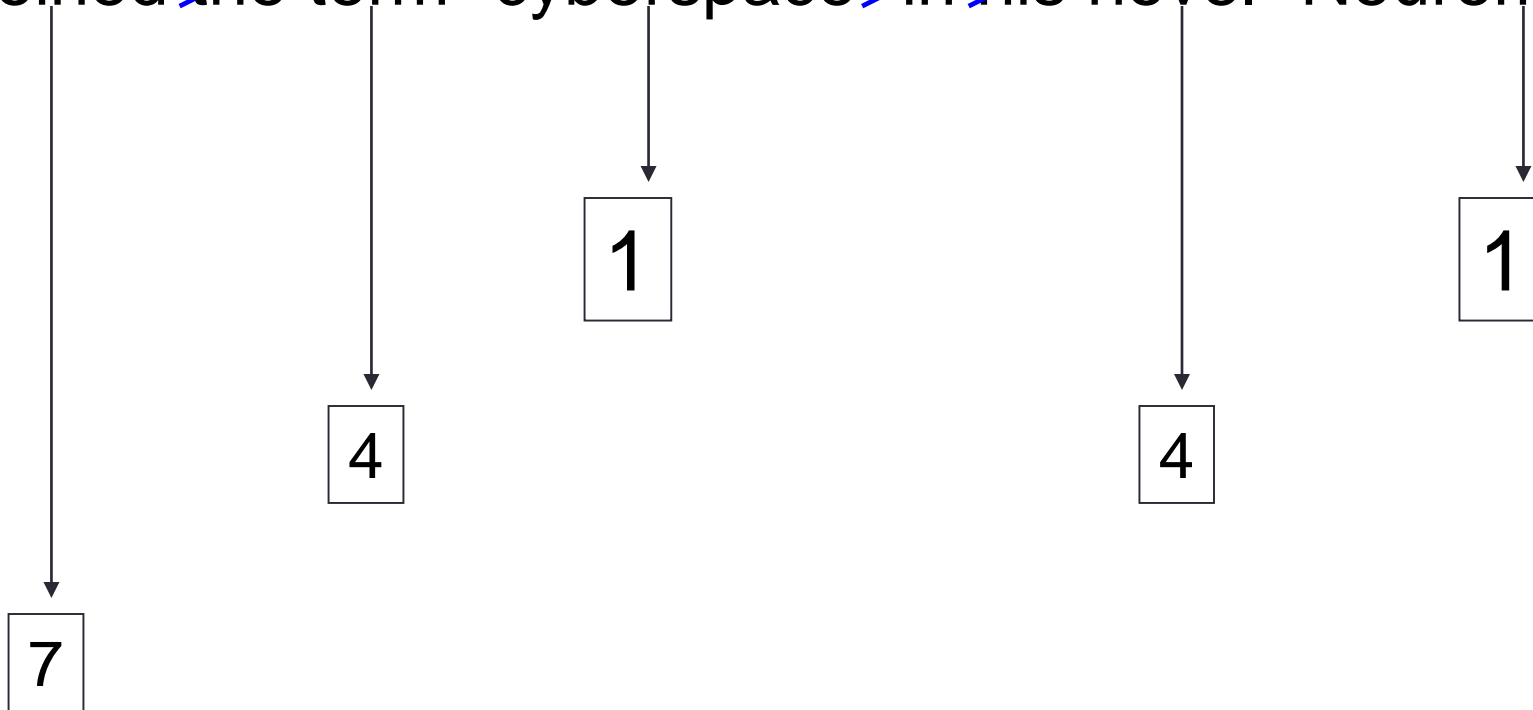
Dan Moldovan, Sanda Harabagiu, Marius Păcă, Rada Mihalcea, Richard Goodrum, Roxana Girju and Vasile Rus. 1999. Proceedings of TREC-8.
<https://web.eecs.umich.edu/~mihalcea/papers/moldovan.trec99.pdf>

1. Select all non-stop words in quotations
2. Select all NNP words in recognized named entities
3. Select all complex nominals with their adjectival modifiers
4. Select all other complex nominals
5. Select all nouns with their adjectival modifiers
6. Select all other nouns
7. Select all verbs
8. Select all adverbs
9. Select the QFW word (skipped in all previous steps)
10. Select all other words

Choosing keywords from the query

Slide from Mihai Surdeanu

~~Who~~ ~~coined~~ ~~the~~ ~~term~~ "cyberspace" ~~in~~ ~~his~~ novel "Neuromancer"?

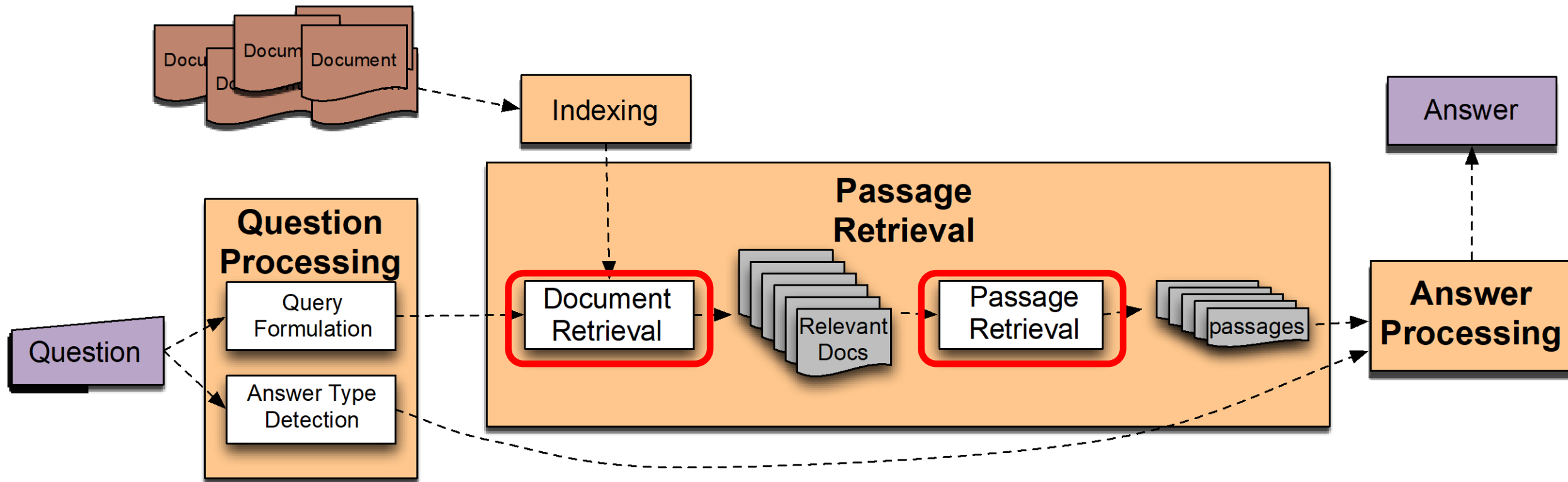


cyberspace/1 Neuromancer/1 term/4 novel/4 coined/7

Question Answering

Passage Retrieval and Answer Extraction

Factoid Q/A



Passage Retrieval

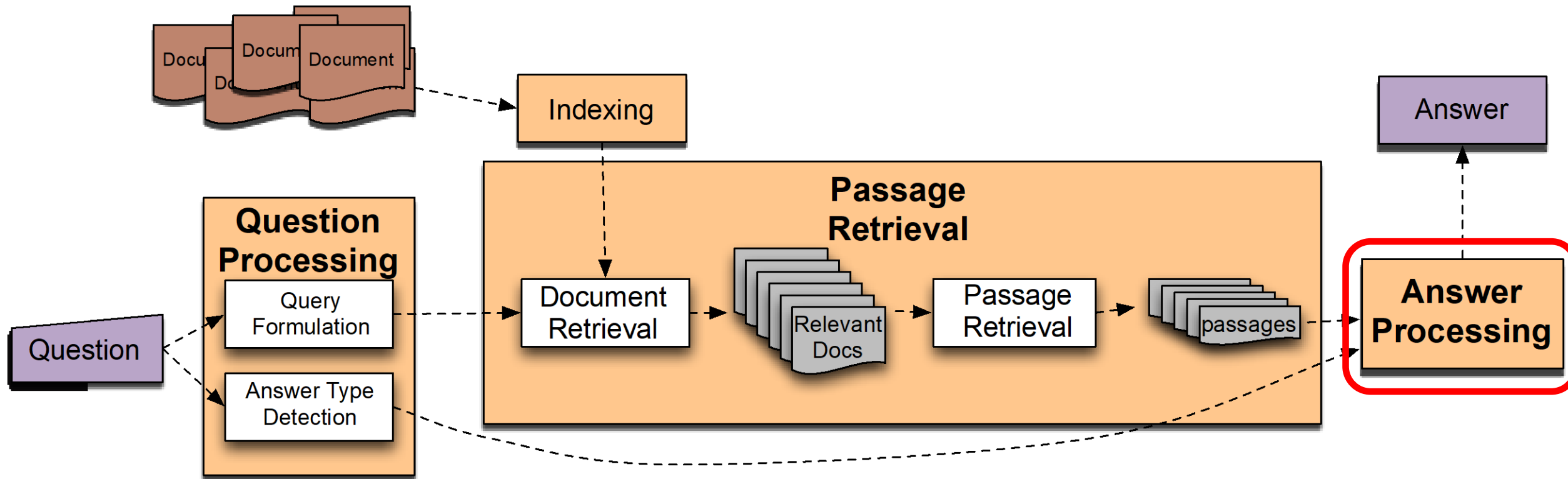
- Step 1: IR engine retrieves documents using query terms
- Step 2: Segment the documents into shorter units
 - something like paragraphs
- Step 3: Passage ranking
 - Use answer type to help rerank passages

Features for Passage Ranking

Either in rule-based classifiers or with supervised machine learning

- Number of Named Entities of the right type in passage
- Number of query words in passage
- Number of question N-grams also in passage
- Proximity of query keywords to each other in passage
- Longest sequence of question words
- Rank of the document containing passage

Factoid Q/A



Answer Extraction

- Run an answer-type named-entity tagger on the passages
 - Each answer type requires a named-entity tagger that detects it
 - If answer type is CITY, tagger has to tag CITY
 - Can be full NER, simple regular expressions, or hybrid
- Return the string with the right type:
 - Who is the prime minister of India (PERSON)
Manmohan Singh, Prime Minister of India, had told left leaders that the deal would not be renegotiated.
 - How tall is Mt. Everest? (LENGTH)
The official height of Mount Everest is **29035 feet**

Ranking Candidate Answers

- But what if there are multiple candidate answers!

Q: Who was Queen Victoria's second son?

- Answer Type: **Person**

- Passage:

The Marie biscuit is named after Marie Alexandrovna, the daughter of Czar Alexander II of Russia and wife of Alfred, the second son of Queen Victoria and Prince Albert

Ranking Candidate Answers

- But what if there are multiple candidate answers!

Q: Who was Queen Victoria's second son?

- Answer Type: **Person**

- Passage:

The Marie biscuit is named after **Marie Alexandrovna**, the daughter of **Czar Alexander II of Russia** and wife of **Alfred**, the second son of **Queen Victoria** and **Prince Albert**

Use machine learning:

Features for ranking candidate answers

Answer type match: Candidate contains a phrase with the correct answer type.

Pattern match: Regular expression pattern matches the candidate.

Question keywords: # of question keywords in the candidate.

Keyword distance: Distance in words between the candidate and query keywords

Novelty factor: A word in the candidate is not in the query.

Apposition features: The candidate is an appositive to question terms

Punctuation location: The candidate is immediately followed by a comma, period, quotation marks, semicolon, or exclamation mark.

Sequences of question terms: The length of the longest sequence of question terms that occurs in the candidate answer.

Candidate Answer scoring in IBM Watson

- Each candidate answer gets scores from >50 components
 - (from unstructured text, semi-structured text, triple stores)
- logical form (parse) match between question and candidate
- passage source reliability
- geospatial location
 - California is "southwest of Montana"
- temporal relationships
- taxonomic classification

Common Evaluation Metrics

1. *Accuracy* (does answer match gold-labeled answer?)

2. *Mean Reciprocal Rank*

- For each query return a ranked list of M candidate answers.
- Query score is 1/Rank of the first correct answer
 - *If first answer is correct: 1*
 - *else if second answer is correct: 1/2*
 - *else if third answer is correct: 1/3, etc.*
 - *Score is 0 if none of the M answers are correct*
- Take the mean over all N queries

e.g. if we returned a list of 5 candidate answers, and the first correct answer is the 3rd in the list (rank 3), then the query score is 1/3

$$MRR = \frac{\sum_{i=1}^N \frac{1}{rank_i}}{N}$$

Question Answering

Using Knowledge in QA

Answer types in Jeopardy

- Answers: Databases of Relations
 - born-in("Emma Goldman", "June 27 1869")
 - author-of("Cao Xue Qin", "Dream of the Red Chamber")
 - Draw from Wikipedia infoboxes, DBpedia, FreeBase, etc.
- Questions: Extracting Relations in Questions

Whose granddaughter starred in E.T.?

`(acted-in ?x "E.T.")`

`(granddaughter-of ?x ?y)`

Temporal Reasoning

- Relation databases
 - (and obituaries, biographical dictionaries, etc.)

- IBM Watson

“In 1594 he took a job as a tax collector in Andalusia”

Candidates:

- Thoreau is a bad answer (born in 1817)
- Cervantes is possible (was alive in 1594)

Geospatial knowledge (containment, directionality, borders)

- **Beijing** is a good answer for "Asian city"
- **California** is "southwest of Montana"
- **geonames.org**:

← → ↻ 🏠 www.geonames.org/search.html?q=palo+alto&country= ☆ 🔍

GeoNames Home | Postal Codes | Download / Webservice | About [login](#)

[\[advanced search\]](#)

459 records found for "palo alto"

	Name	Country	Feature class	Latitude	Longitude
1 📍	Palo Alto Palo Al'to, Palo Alto, pa luo ao duo, paroaruto, Пало Алто, Пало Альто, פאלו אלטו, パロアルト, 帕羅奧多	United States , California Santa Clara County	populated place population 64,403, elevation 9m	N 37° 26' 30"	W 122° 8' 34"
2 📍	Palo Alto Township Palo Alto Township	United States , Iowa Jasper County	administrative division elevation 256m	N 41° 38' 15"	W 93° 2' 57"
3 📍	Borough of Palo Alto	United States , Pennsylvania Schuylkill County	administrative division population 1,032, elevation 210m	N 40° 41' 21"	W 76° 10' 2"

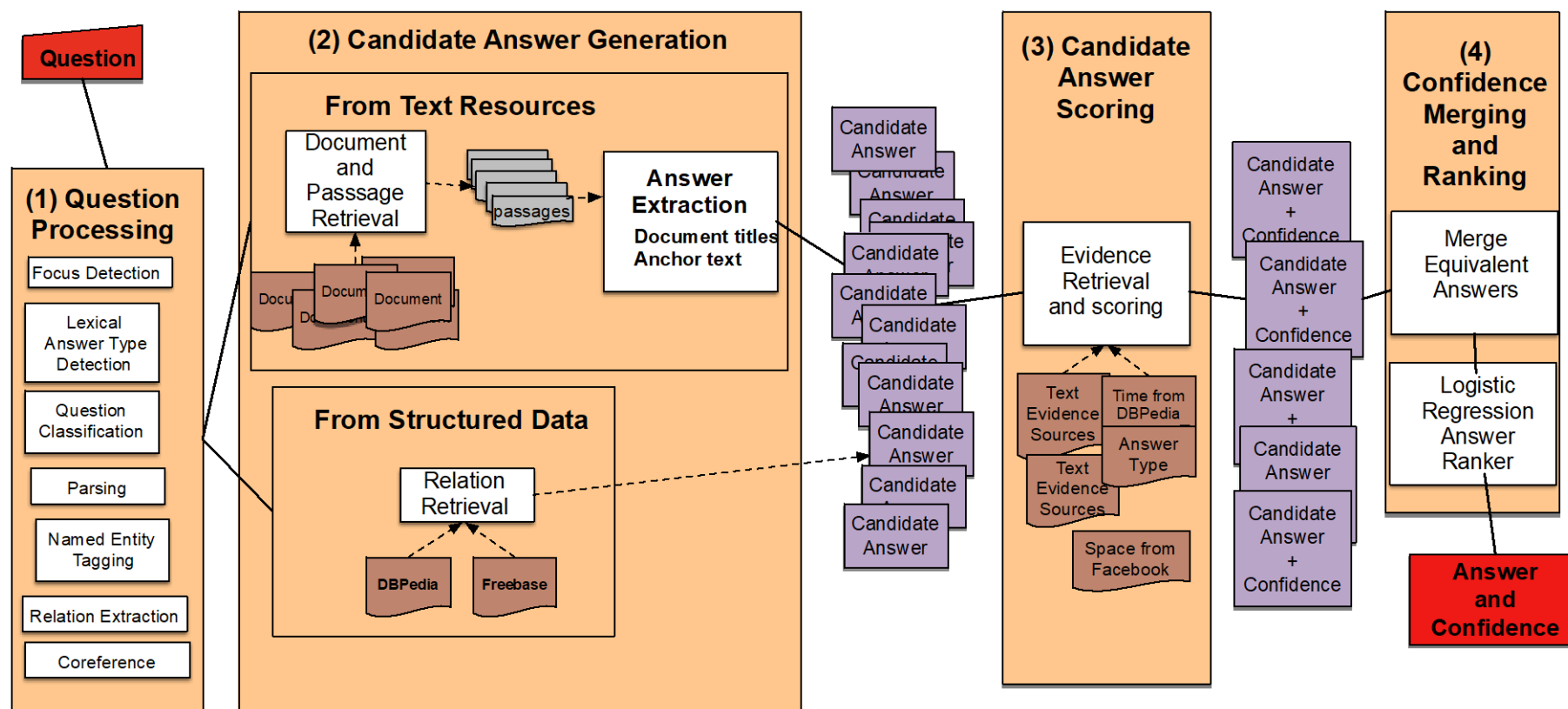
Context and Conversation in Virtual Assistants like Siri

- Coreference helps resolve ambiguities
 - U: “Book a table at Il Fornaio at 7:00 with **my mom**”
 - U: “Also send **her** an email reminder”
- Clarification questions:
 - U: “Chicago pizza”
 - S: “Did you mean pizza restaurants in Chicago or Chicago-style pizza?”

QA Systems

Watson DeepQA System

Watson DeepQA System – Watson Architecture



Stage 1: Question Processing

- Parsing
- Named Entity Tagging
- Relation Extraction
- Focus
- Answer Type
- Question Classification

Stage 1: Question Processing

Named Entity and Parse Focus Answer Type Relation Extraction

Poets and Poetry: **He** was a bank clerk in the **Yukon** before he published **"Songs of a Sourdough"** in **1907**.

GEO

COMPOSITION

YEAR

PERSON

THEATRE: A new play based on **this** **Sir Arthur Conan Doyle** **canine classic** opened on the **London** stage in **2007**.

GEO

YEAR

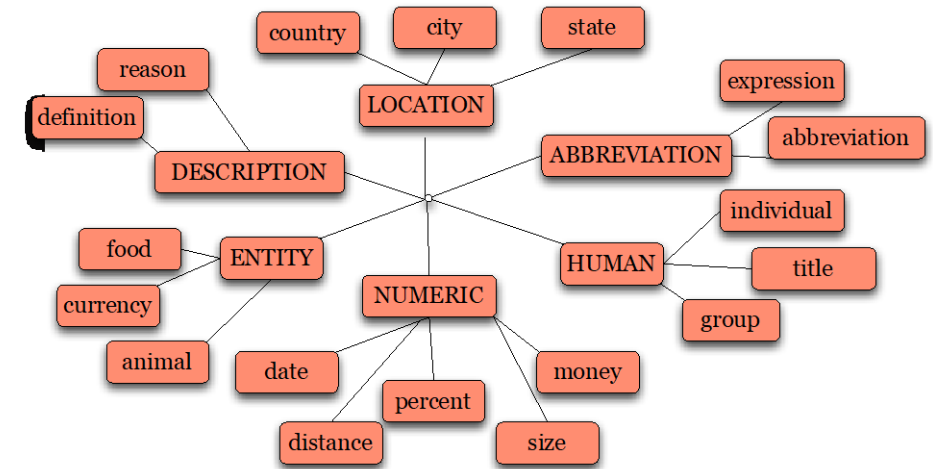
authorof(focus, "Songs of a sourdough")
 publish (e1, he, "Songs of a sourdough")
 in (e2, e1, 1907)
 temporallink(publish(...), 1907)

Focus Extraction

- **Focus:** the part of the question that co-refers with the answer
- Replace it with answer to find a supporting passage.
- Extracted by hand-written rules
 - "Extract any noun phrase with determiner this"
 - "Extracting pronouns *she, he, hers, him,* "

Lexical Answer Type

- The semantic class of the answer
- But for Jeopardy the TREC answer type taxonomy is insufficient
- DeepQA team investigated 20,000 questions
- 100 named entities only covered <50% of the questions!
- Instead: Extract lots of words: 5,000 for those 20,000 questions



Lexical Answer Type

- Answer types extracted by hand-written rules
 - Syntactic headword of the focus.
 - Words that are coreferent with the focus
 - Jeopardy! category, if refers to compatible entity.

***Poets** and Poetry: **He** was a bank **clerk** in the Yukon before he published “Songs of a Sourdough” in 1907.*

Relation Extraction in DeepQA

- For the most frequent 30 relations:
 - Hand-written regular expressions
 - AuthorOf:
 - Many patterns such as one to deal with:
 - *a Mary Shelley tale, the Saroyan novel, Twain's travel books, a1984 Tom Clancy thriller*
 - [Author] [Prose]
- For the rest: distant supervision

Stage 2: Candidates Answer Generation

Extracting Candidate Answers from Triple Stores

- If we extracted a relation from the question
... he published “Songs of a sourdough”
(author-of ?x “Songs of a sourdough”)
- We just query a triple store
 - Wikipedia infoboxes, DBpedia, FreeBase, etc.
 - born-in(“Emma Goldman”, “June 27 1869”)
 - author-of(“Cao Xue Qin”, “Dream of the Red Chamber”)
 - author-of(“Songs of a sourdough”, “Robert Service”)

Extracting candidate answers from text: get documents / passages

1. Do standard IR-based QA to get documents

Robert Redford and Paul Newman starred in this depression-era grifter flick.

(2.0 Robert Redford) (2.0 Paul Newman) star depression era grifter (1.5 flick)

Extracting answers from documents / passages

- Useful fact: Jeopardy! answers are mostly the title of a Wikipedia document
 - If the document is a Wikipedia article, just take the title
 - If not, extract all noun phrases in the passage that are Wikipedia document titles
 - Or extract all anchor text `<a>The Sting`

Stage 3: Candidate Answer Scoring

- Use lots of sources of evidence to score an answer
 - more than 50 scorers
- **Lexical answer type** is a big one
 - Different in DeepQA than in pure IR factoid QA
 - In pure IR factoid QA, answer type is used to strictly filter answers
 - In DeepQA, answer type is just one of many pieces of evidence

Lexical Answer Type (LAT) for Scoring Candidates

- Given:
 - candidate answer & lexical answer type
 - Return a score: can answer can be a subclass of this answer type?
 - Candidate: “*difficulty swallowing*” & LAT “*condition*”
1. Check DBPedia, WordNet, etc
 - *difficulty swallowing* -> Dbpedia *Dysphagia* -> WordNet *Dysphagia*
 - *condition* -> WordNet *Condition*
 2. Check if “Dysphagia” IS-A “Condition” in WordNet
 - [Wordnet for dysphagia](#)

Relations for Scoring

- **Q:** This hockey defenseman ended his career on June 5, 2008
- **Passage:** On June 5, 2008, Wesley announced his retirement after his 20th NHL season
- Question and passage have very few keywords in common
- But both have the Dbpedia relation `ActiveYearsEndDate()`

Temporal Reasoning for Scoring Candidates

- Relation databases
 - (and obituaries, biographical dictionaries, etc.)
- IBM Watson

”In 1594 he took a job as a tax collector in Andalusia”

Candidates:

- Thoreau is a bad answer (born in 1817)
- Cervantes is possible (was alive in 1594)

Geospatial knowledge (containment, directionality, borders)

- Beijing is a good answer for "Asian city"
- California is "southwest of Montana"
- geonames.org:

← → ↻ 🏠 www.geonames.org/search.html?q=palo+alto&country= ☆ 🔍

GeoNames Home | Postal Codes | Download / Webservice | About [login](#)

[\[advanced search\]](#)

459 records found for "palo alto"

	Name	Country	Feature class	Latitude	Longitude
1 📍	Palo Alto Palo Al'to, Palo Alto, pa luo ao duo, paroaruto, Пало Алто, Пало Альто, פאלו אלטו, パロアルト, 帕羅奧多	United States , California Santa Clara County	populated place population 64,403, elevation 9m	N 37° 26' 30"	W 122° 8' 34"
2 📍	Palo Alto Township Palo Alto Township	United States , Iowa Jasper County	administrative division elevation 256m	N 41° 38' 15"	W 93° 2' 57"
3 📍	Borough of Palo Alto	United States , Pennsylvania Schuylkill County	administrative division population 1,032, elevation 210m	N 40° 41' 21"	W 76° 10' 2"

Text-retrieval-based answer scorer

- Generate a query from the question and retrieve passages
- Replace the focus in the question with the candidate answer
- See how well it fits the passages.
- Robert Redford and Paul Newman starred in **this depression-era grifter flick**
- Robert Redford and Paul Newman starred in The Sting

Robert Redford - Wikipedia, the free encyclopedia

en.wikipedia.org/wiki/Robert_Redford ▼ Wikipedia ▼

Redford starred in Sydney Pollack's Out of Africa (1985), which was an by William Goldman, in which he was paired for the first time with **Paul Newman**. ... the blockbuster crime caper The **Sting** (1973), which became one of the top 20 ...

Stage 4: Answer Merging and Scoring

- Now we have a list candidate answers each with a score vector
 - J.F.K [.5 .4 1.2 33 .35 ...]
 - John F. Kennedy [.2 .56 5.3 2 ...]
- Merge equivalent answers: *J.F.K.* and *John F. Kennedy*
 - Use Wikipedia dictionaries that list synonyms:
 - *JFK, John F. Kennedy, John Fitzgerald Kennedy, Senator John F. Kennedy, President Kennedy, Jack Kennedy*
 - Use stemming and other morphology

Stage 4: Answer Scoring

- Build a classifier to take answers and a score vector and assign a probability
- Train on datasets of hand-labeled correct and incorrect answers.

Conversational Agents

What are Conversational Agents

Conversational Agents

AKA Dialog Agents

Phone-based Personal Assistants

SIRI, Cortana, Google Now

Talking to your car

Communicating with robots

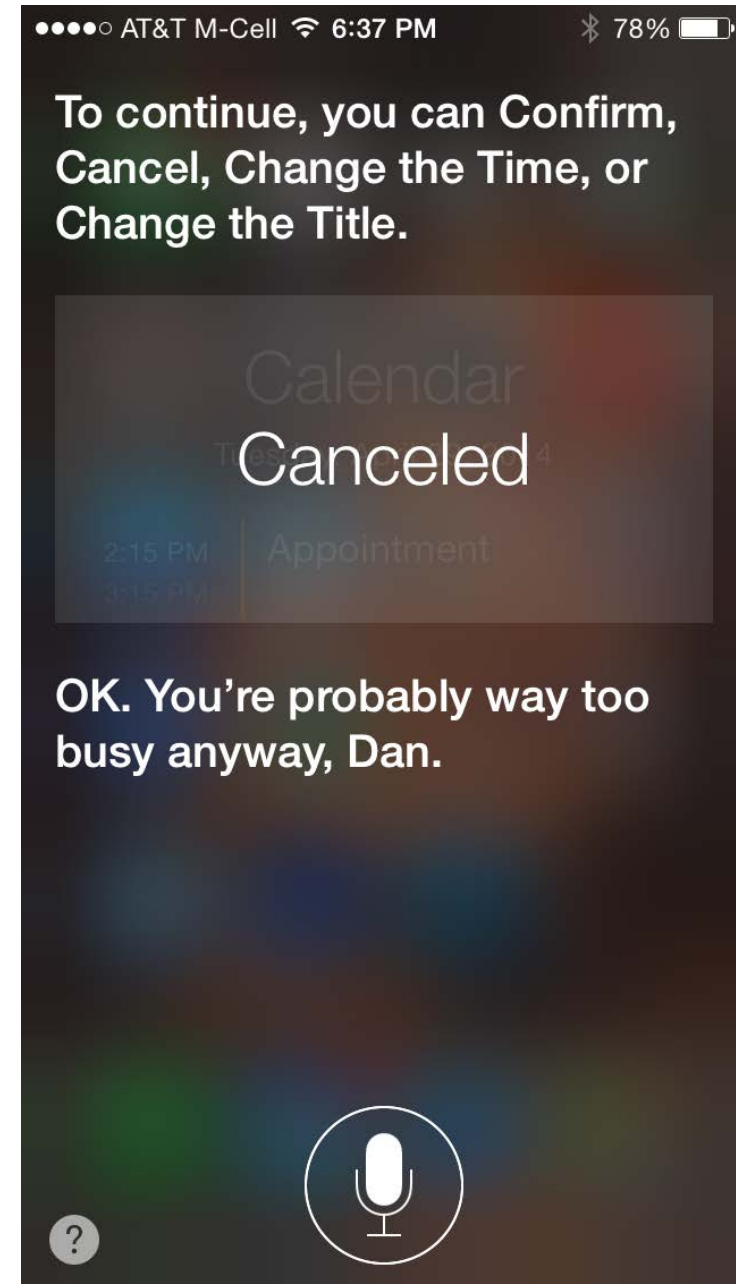
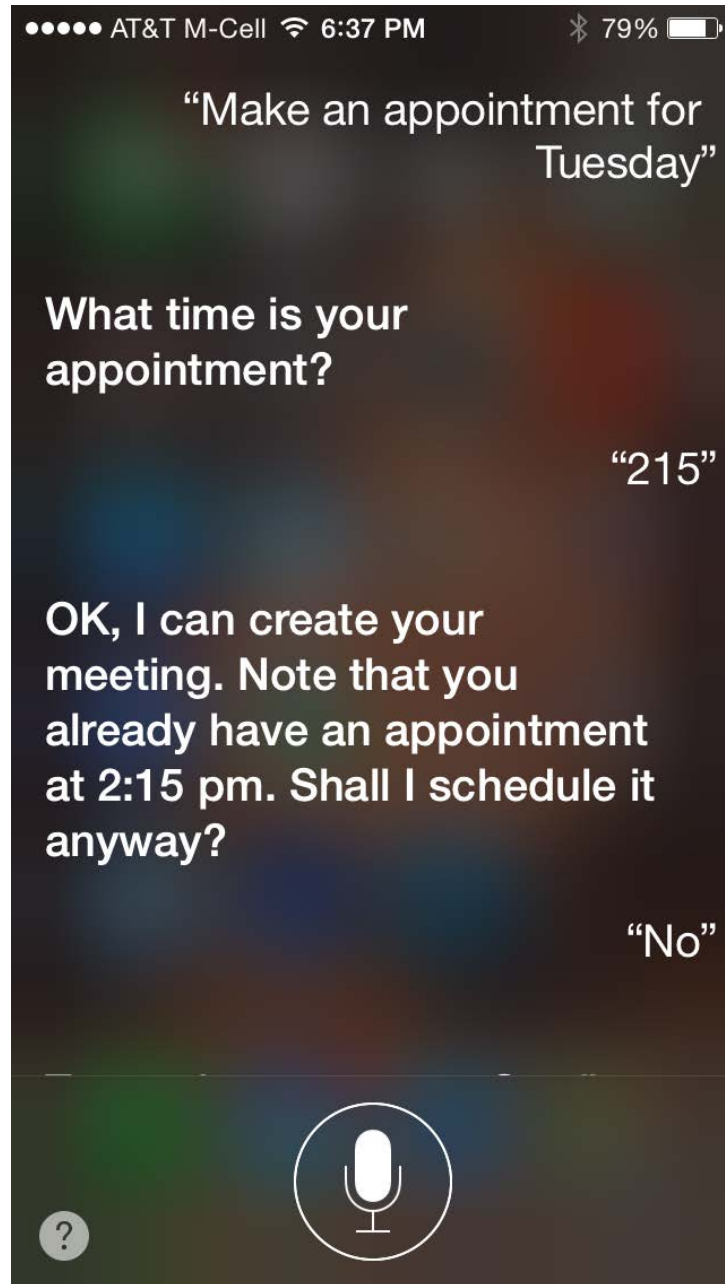
Clinical uses for mental health

Chatting for fun

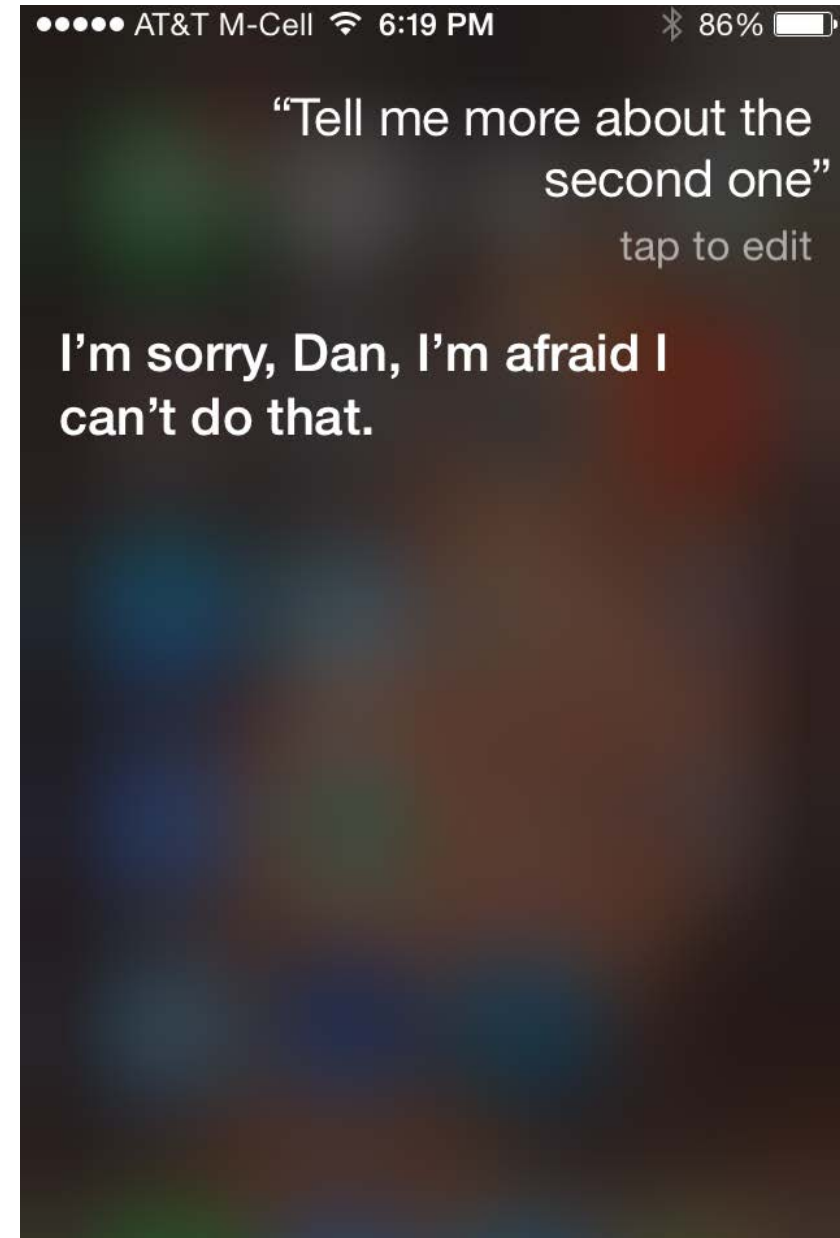
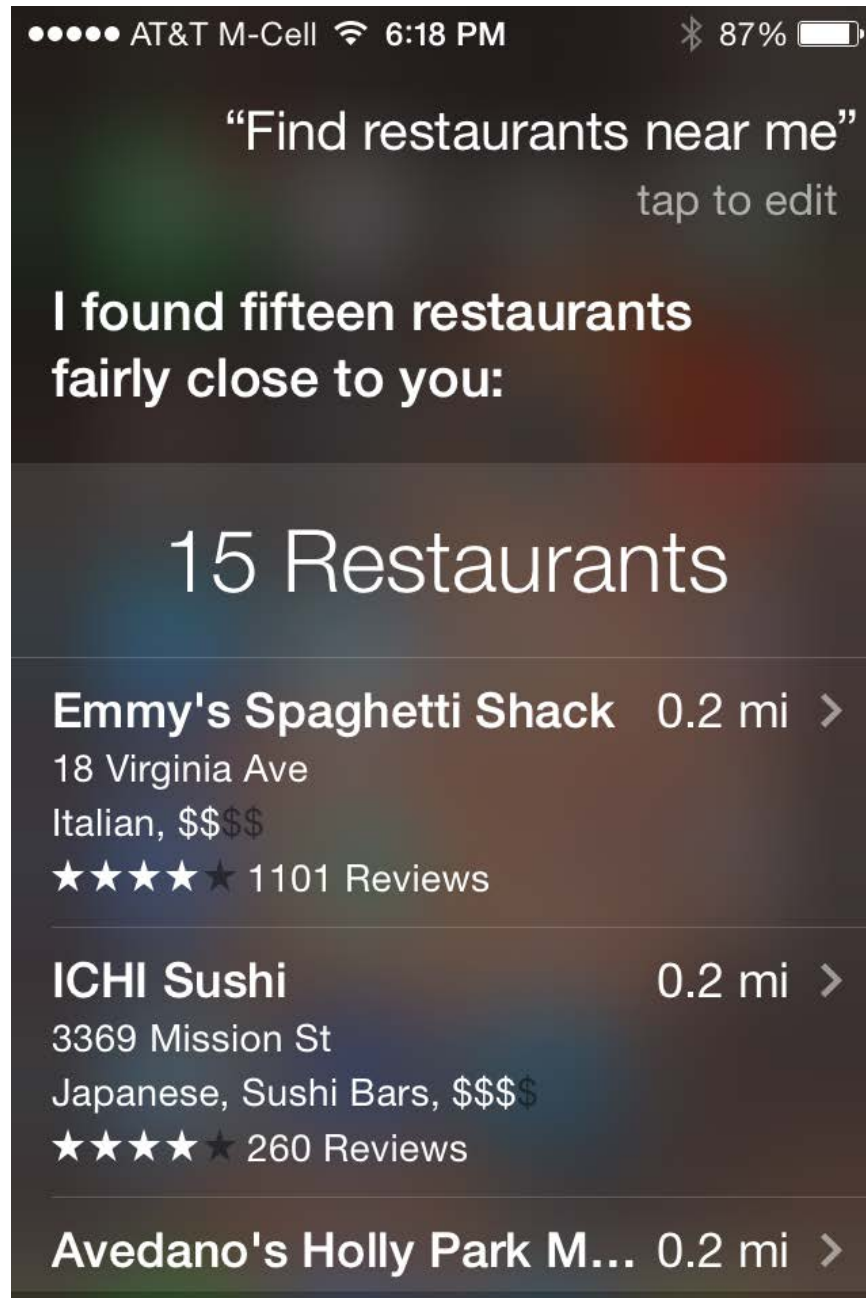
Two classes of systems

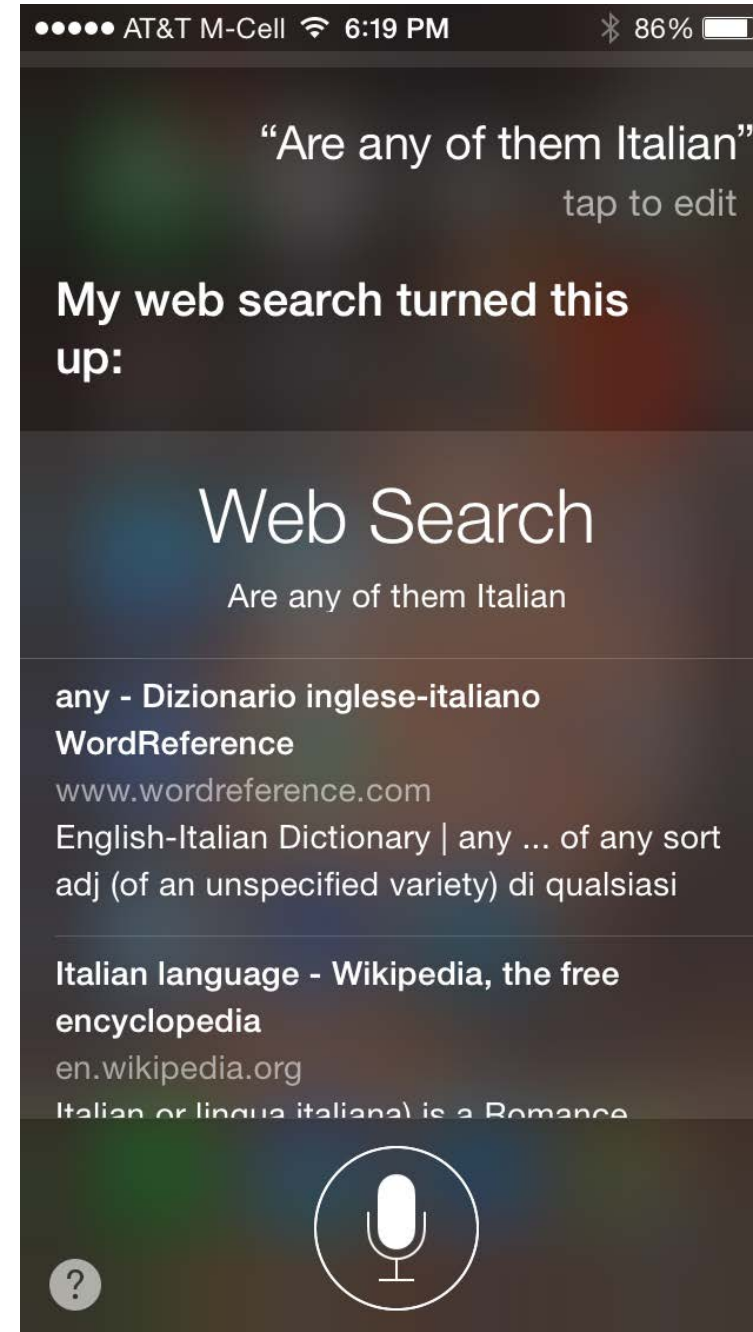
1. (Goal-based) Dialog agents
 - *SIRI, interfaces to cars, robots,*
 - *booking flights or restaurants*
2. Chatbots

Recently I've noticed that the word "chatbots" is sometimes used in the popular press for both

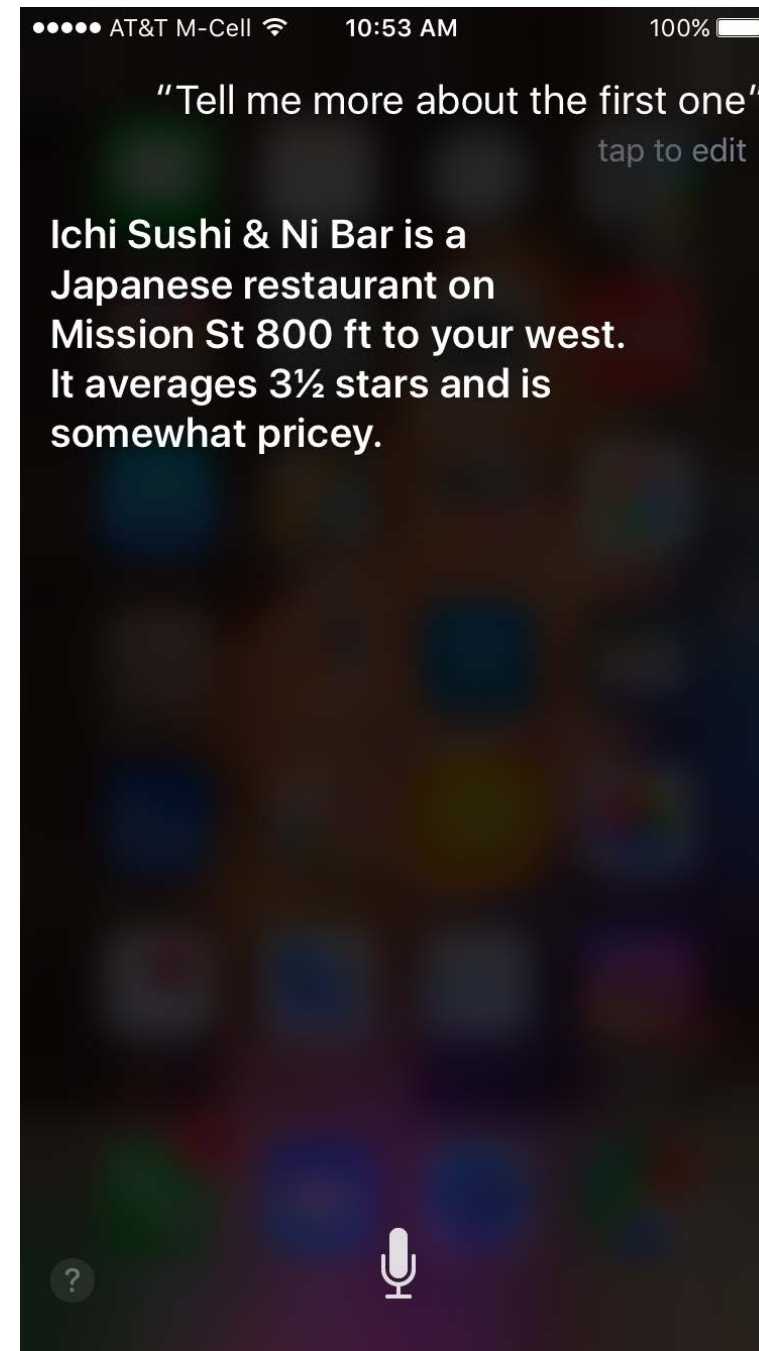
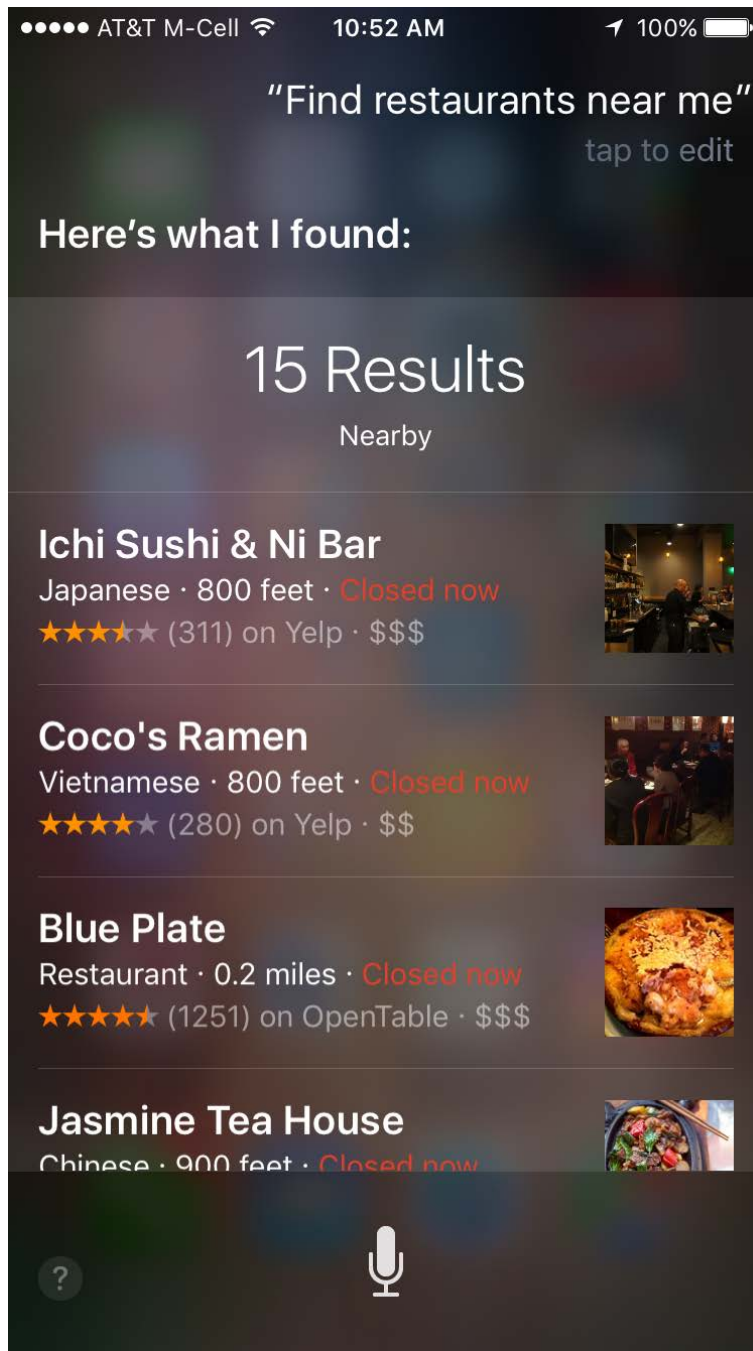


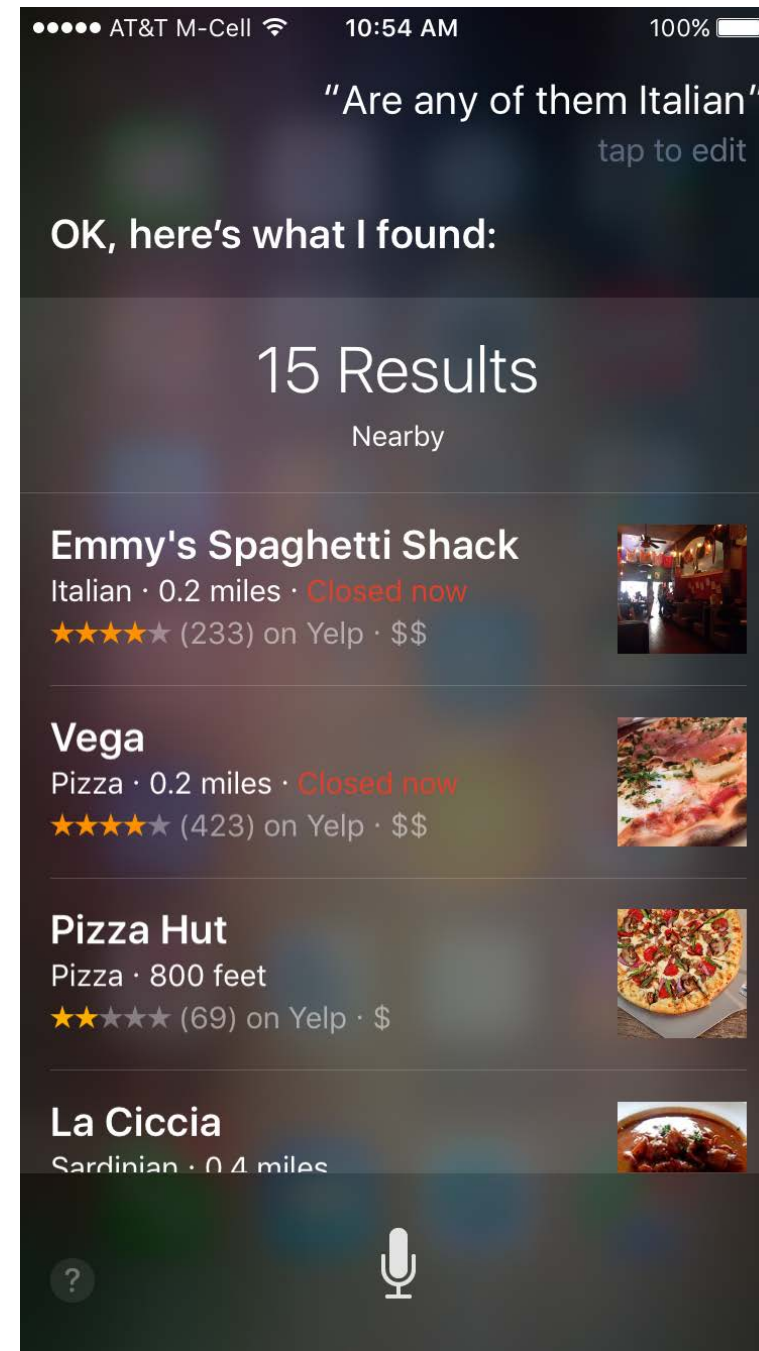
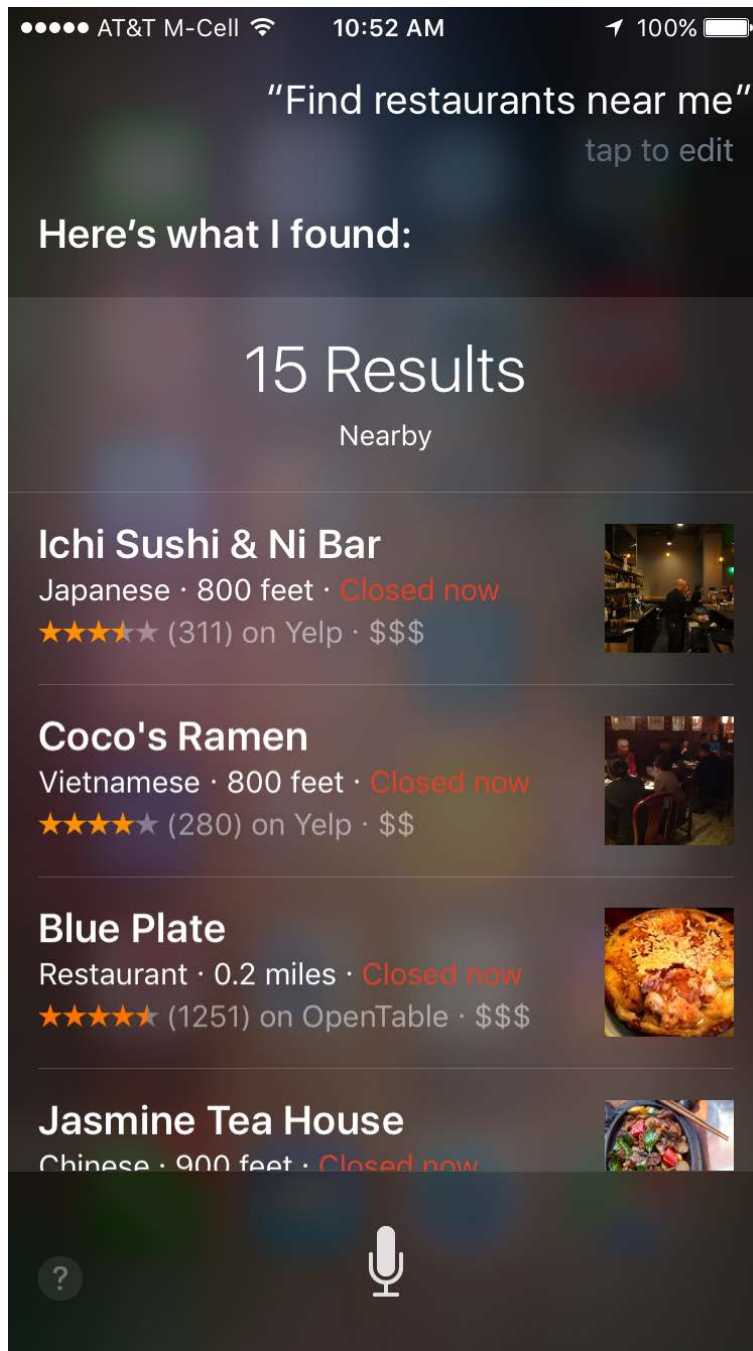
SIRI around 2016





SIRI in February 2017





Architectures for Practical Dialog Systems

- Finite-State
Just for passwords or credit cards
- Frame-Based
*All commercial and academic system
(SIRI etc.)*

How SIRI works

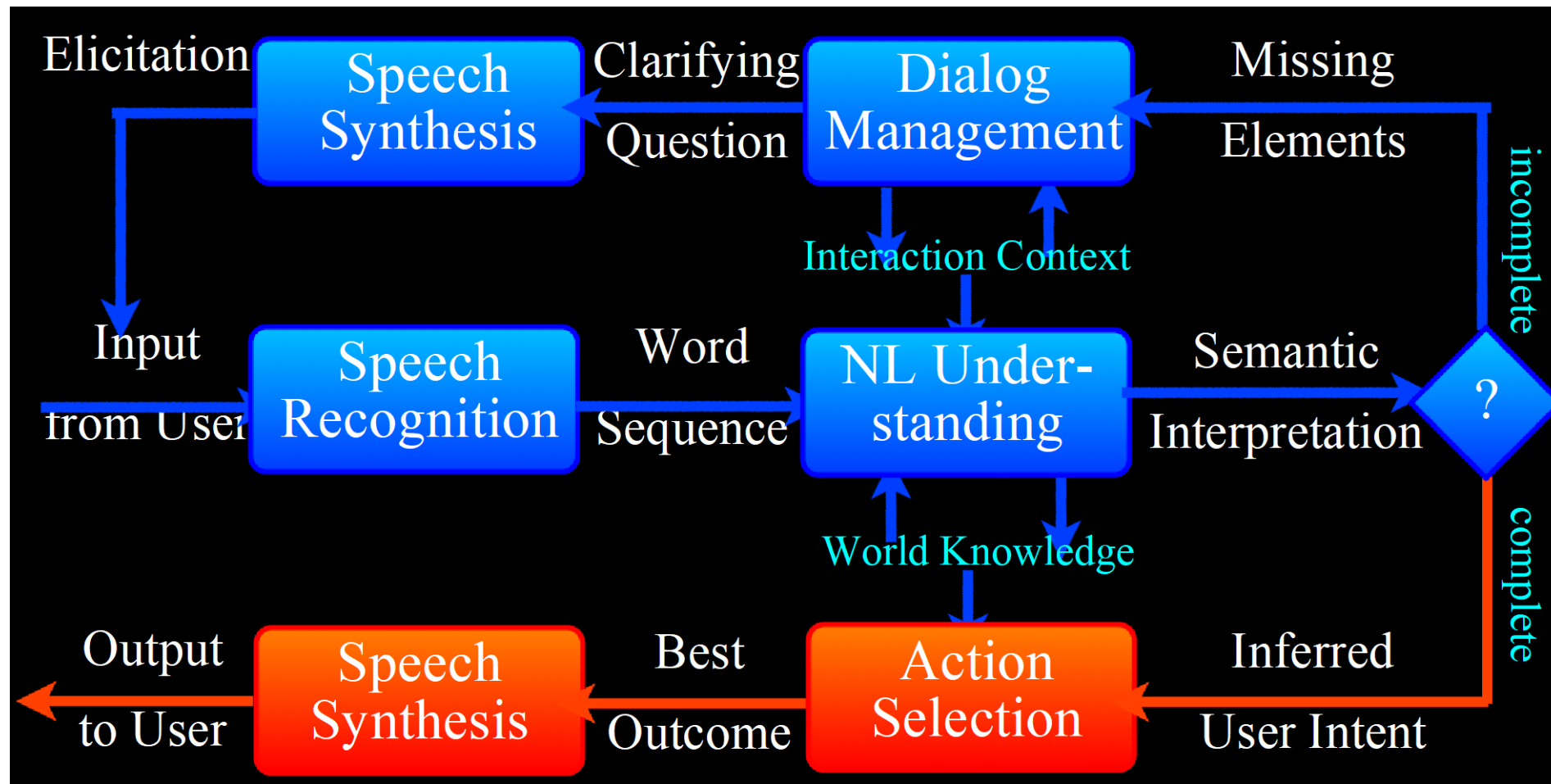


Figure from Jerome Bellegarda

Finite-State Dialog Management

Consider a trivial airline travel system:

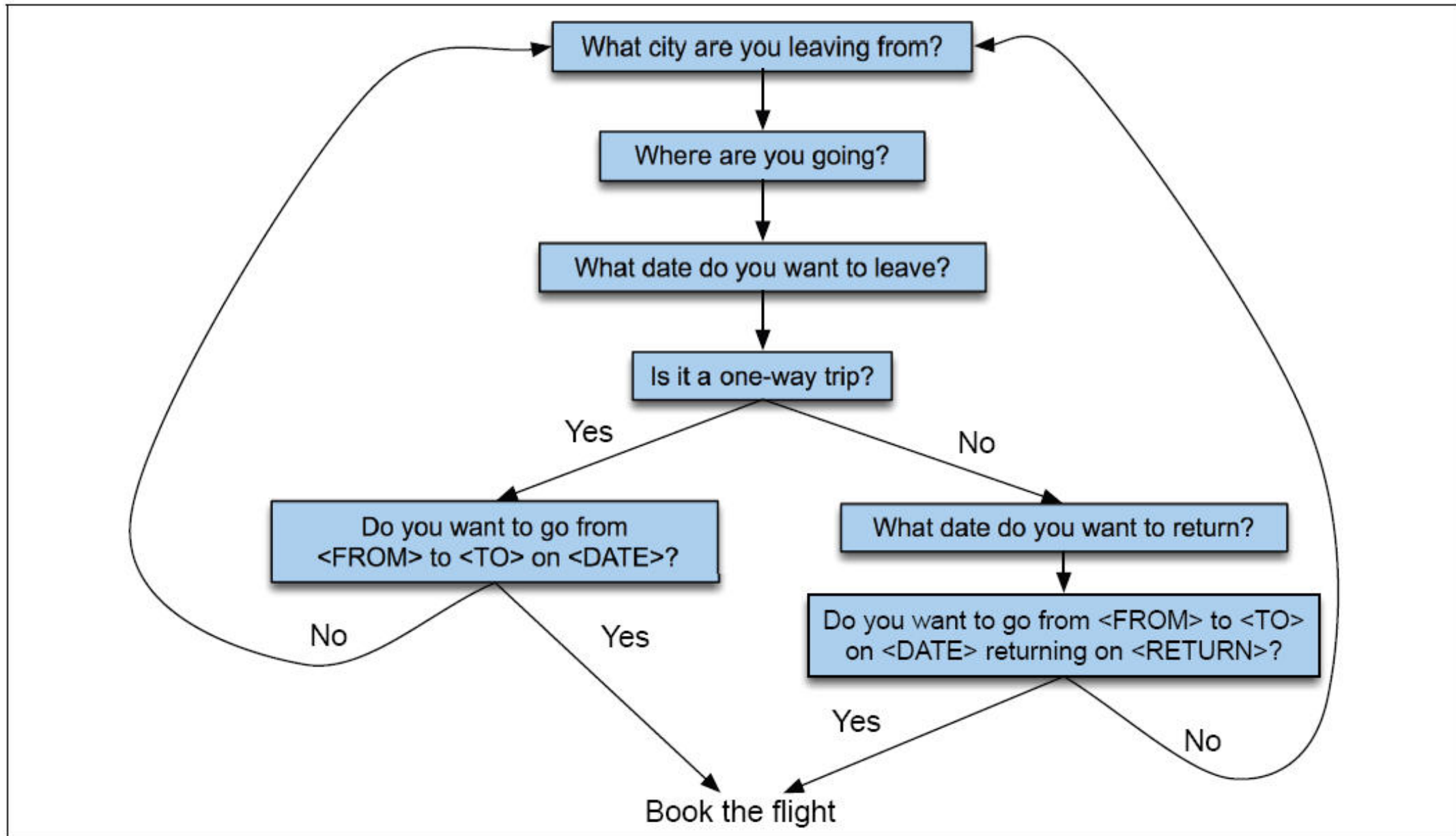
- Ask the user for a departure city

- Ask for a destination city

- Ask for a time

- Ask whether the trip is round-trip or not

Finite State Dialog Manager



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 called **single initiative**. (system 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

Instead, the state of the art: Frame-based dialogue

- A kind of ***mixed initiative***
 - The conversational initiative shifts between system and user
- The structure of the **frame** guides dialogue

Frame-based dialogue

- Invented up the hill in 1977:

versation with a client who wants to make a simple return trip to a single city in California.

There is good reason for restricting the domain of discourse for a computer system which is to engage in an English dialog. Specializing the subject matter that the system can talk about permits it to achieve some measure of realism without encompassing all the possibilities of human knowledge or of the English language. It also provides the user with specific motivation for participating in the conversation, thus narrowing the range of expectations that GUS must have about the user's purposes. A system restricted in this way will be more able to guide the conversation within the boundaries of its competence.

Artificial Intelligence Journal, 1977

- Still the state of the art
 - SIRI based on GUS architecture

The Frame

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

Slot

ORIGIN

DEST

DEPT DATE

DEPT TIME

AIRLINE

Question

What city are you leaving from?

Where are you going?

What day would you like to leave?

What time would you like to leave?

What is your preferred airline?

Frames are mixed-initiative

- 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 can fill 3 slots and not ask these questions again!

The Natural Language Understanding Component

Show me morning flights from Boston to SF on Tuesday.

SHOW:

FLIGHTS:

ORIGIN:

CITY: Boston

DATE: Tuesday

TIME: morning

DEST:

CITY: San Francisco

Often called "dialog state" detection

Dialog state: representation of what the user wants at any point in a dialog

- Which slots got filled in the last sentence?
- What is the current state of the frame?
 - All the values of the filled slots
- What is the user's last "dialogue act":
 - Did they ask me a **question**?
 - **Inform** me of something?

How to do Frame-based Natural Language Understanding?

Rule-based
Statistical

Siri uses GUS architecture:

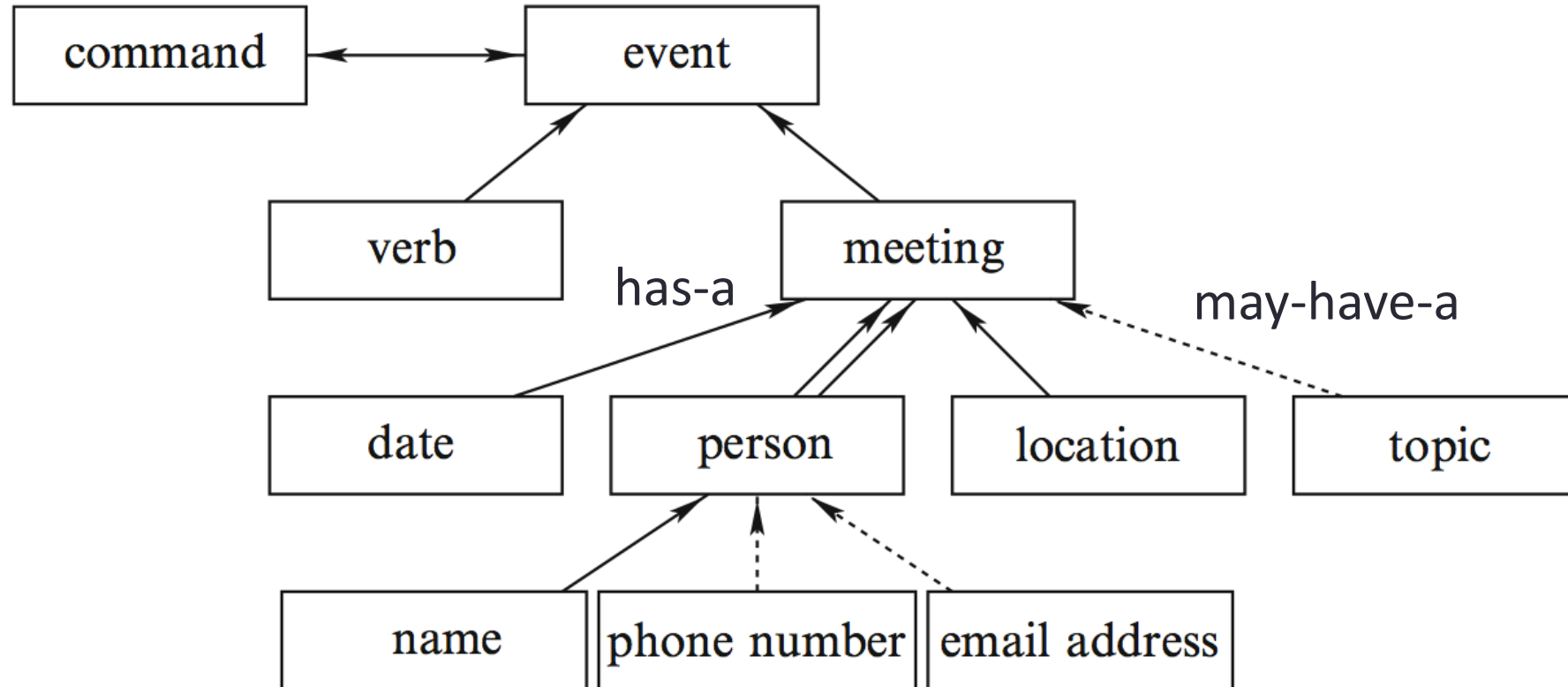
Condition-Action Rules

- 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
`date(DAY,MONTH,YEAR,HOURS,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

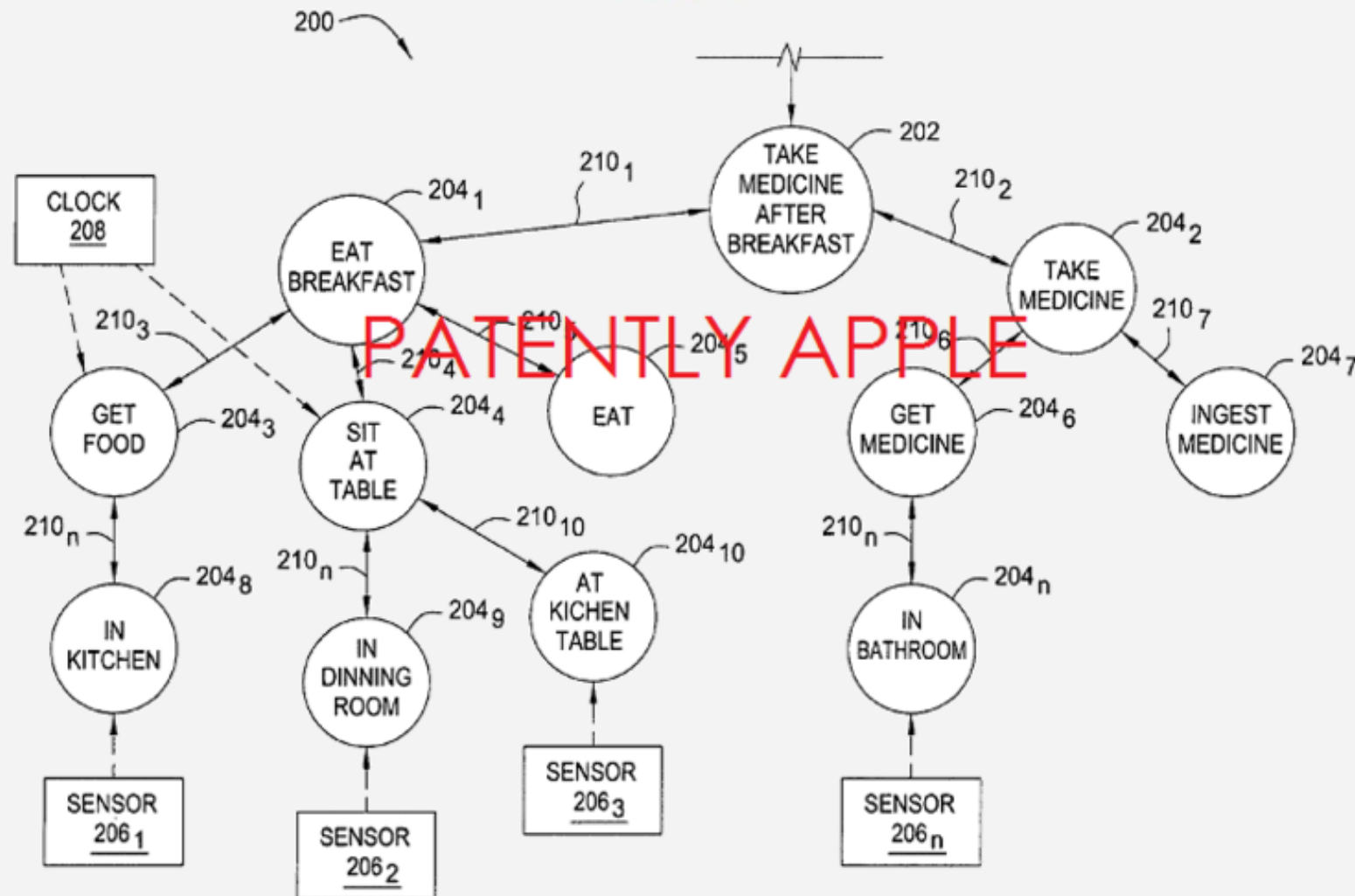
Part of ontology for meeting task



meeting concept: if you don't yet have a location, ask for a location

Apple Granted Patent for Advancements in Siri: Auto Reminder System

FIG. 2



Statistical Natural Language Understanding

- 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

Statistical Slot filling

- Given a sentence:

I want to go to Santa Fe

- Classifier predicts which slot the user wants to fill

Output: (ORIGIN, DESTINATION, DEPARTURE-DATE, AIRLINE)

Features: Words, Named Entities

- Classifier or sequence model predicts the filler:

ORIGIN DEST

I want to go from Boston to SF

Evaluation

1. Slot Error Rate for a Sentence
$$\frac{\text{\# of inserted/deleted/substituted slots}}{\text{\# of total reference slots for sentence}}$$
2. End-to-end evaluation (Task Success)

Evaluation Metrics

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

Slot	Filler
PERSON	Chris
TIME	11:30 a.m.
ROOM	Gates 104

Slot error rate: 1/3

Task success: At end, was the correct meeting added to the calendar?

Dialog Act Detection

- Dialog Act: The dialog function of the sentence
 - Question
 - Command
 - Suggestion
- Given a user's sentence:
 - How many Italian restaurants are in walking distance?
- Was that a question?

Dialogue Act detection is hard

Can you give me a list of the flights from Atlanta to Boston?

- This looks like an QUESTION.
 - It has a question-mark, starts with "can you"
- If so, the answer is:
 - YES.
- But really it's a COMMAND, a polite form of:

Please give me a list of the flights...
- What looks like a QUESTION can be a COMMAND

Dialogue Act detection

Rules

Statistical Classifiers

Another example of dialogue act detection: Correction Detection

- If system misrecognizes an utterance, and either
 - Rejects
 - Via confirmation, displays its misunderstanding
- Then user has a chance to make a **correction**
 - Repeat themselves
 - Rephrasing
 - Saying “no” to the confirmation question.

Corrections

- Unfortunately, corrections are harder to recognize than normal sentences!
 - Swerts et al (2000): corrections misrecognized twice as often as non-corrections!!!
 - Why?
 - Prosody seems to be largest factor:
hyperarticulation
 - Liz Shriberg example:
 - “NO, I am DE-PAR-TING from Jacksonville”
- Bettina Braun example from a talking elevator
 - “In den VIERTEN Stock”



A Labeled dialogue (Swerts et al)

Turn	Corr Type
S On which day of the week do you want to leave?	
S Sorry, I didn't hear anything from you. Please tell me your departure date	
U <i>Um tomorrow</i>	NA
S You can say the departure date. For example, you can say 'today' or 'tomorrow'. Or you can say 'Monday', 'Tuesday', 'Wednesday'...	
U <i>Tomorrow</i>	REP
S You can say the departure date. For example, you can say 'today' or 'tomorrow'. Or you can say 'Monday', 'Tuesday', 'Wednesday'...	
U <i>Saturday</i>	PAR
S Do you want to leave on Saturday?	
U Yes	
S What time do you want to leave?	
U Eight o'clock A M	
S Do you want to leave around ten oclock p-m	
U <i>Eight o'clock</i>	OMIT
S Do you want to leave around ten oclock p-m	
U <i>No</i>	OMIT
S What time do you want to leave?	
U <i>Eight o'clock A M</i>	ADD

Machine learning to detect user corrections: features

- Lexical information (no, correction, I don't, swear words)
- Prosodic indicators of hyperarticulation
 - increases in F0 range, pause duration, word duration
- Length
- ASR confidence
- LM probability
- Various dialogue features (repetition)

Deciding what to say:

Dialog act generation

Should I do a "*Confirmation*" dialog act?

Natural Language Generation

Given that I'm confirming, what exactly should I say?

Grounding

- Why do elevator buttons light up?
- Clark (1996) (after Norman 1988)

Principle of closure. Agents performing an action require evidence, sufficient for current purposes, that they have succeeded in performing it

- What is the linguistic correlate of this?

Grounding and Confirmation

- We need to know whether an action succeeded or failed
- Talking is an action!
- I need to know if my action succeeded
 - i.e. the hearer understood my turn!

How do speakers ground?

Clark and Schaefer

- Continued attention:
 - B continues attending to A
- Relevant next contribution:
 - B starts in on next relevant contribution
- Acknowledgement:
 - B nods or says continuer (**uh-huh**) or assessment (**great!**)
- Demonstration:
 - B demonstrates understanding A by **reformulating** A's contribution, or by **collaboratively completing** A's utterance
- Display:
 - B repeats verbatim all or part of A's presentation

A human-human conversation

C₁: ...I need to travel in May.
A₁: And, what day in May did you want to travel?
C₂: OK uh I need to be there for a meeting that's from the 12th to the 15th.
A₂: And you're flying into what city?
C₃: Seattle.
A₃: And what time would you like to leave Pittsburgh?
C₄: Uh hmm I don't think there's many options for non-stop.
A₄: Right. There's three non-stops today.
C₅: What are they?
A₅: The first one departs PGH at 10:00am arrives Seattle at 12:05 their time. The second flight departs PGH at 5:55pm, arrives Seattle at 8pm. And the last flight departs PGH at 8:15pm arrives Seattle at 10:28pm.
C₆: OK I'll take the 5ish flight on the night before on the 11th.
A₆: On the 11th? OK. Departing at 5:55pm arrives Seattle at 8pm, U.S. Air flight 115.
C₇: OK.

Grounding examples

Display:

C: I need to travel in May

A: And, what day in May did you want to travel?

Acknowledgement

C: He wants to fly from Boston

A: mm-hmm

C: to Baltimore Washington International

Grounding Examples (2)

- Acknowledgement + next relevant contribution
And, what day in May did you want to travel?
And you're flying into what city?
And what time would you like to leave?
- The **and** indicates to the client that agent has successfully understood answer to the last question.

Grounding negative responses

From Cohen et al. (2004)

- System: Did you want to review some more of your personal profile?
- Caller: No.
- System: Okay, what's next?

Good!

- System: Did you want to review some more of your personal profile?
- Caller: No.
- System: What's next?

Bad!

Confirmation

- Errors: Speech is a pretty errorful channel
 - Humans use grounding to confirm that they heard correctly
 - ASR is way worse than humans!
- Dialog systems need to do even more grounding and confirmation than humans
 - Users are confused when system doesn't give explicit acknowledgement signal.

Stifelman et al. (1993), Yankelovich et al. (1995)

Explicit confirmation

S: Which city do you want to leave from?

U: Baltimore

S: Do you want to leave from Baltimore?

U: Yes

Explicit confirmation

U: I'd like to fly from Denver Colorado to New York City on September 21st in the morning on United Airlines

S: Let's see then. I have you going from Denver Colorado to New York on September 21st. Is that correct?

U: Yes

Implicit confirmation: display

U: I'd like to travel to Berlin

S: When do you want to travel to Berlin?

U: Hi I'd like to fly to Seattle Tuesday morning

S: Traveling to Seattle on Tuesday, August eleventh in the morning. Your name?

Implicit vs. Explicit

- Complementary strengths
- Explicit: easier for users to correct systems' mistakes (can just say "no")
- But explicit is cumbersome and long
- Implicit: much more natural, quicker, simpler (if system guesses right).

Implicit and Explicit

- Early systems: all-implicit or all-explicit
- Modern systems: adaptive
- How to decide?
 - ASR system can give confidence metric.
 - This expresses how convinced system is of its transcription of the speech
 - If high confidence, use implicit confirmation
 - If low confidence, use explicit confirmation
- Should also consider cost of an error: Explicit confirmation before moving money or booking flights

Rejection

- “I’m sorry, I didn’t understand that.”
- Reject when:
 - ASR confidence is low
 - Best interpretation is semantically ill-formed
- Might have four-tiered level of confidence:
 - Below confidence threshold, reject
 - Above threshold, explicit confirmation
 - If even higher, implicit confirmation
 - Even higher, no confirmation

Part II: Chatbots!

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

Chatbot Architectures

- Rule-based
 - Pattern-action rules (Eliza)
 - + a mental model (Parry)
- Corpus-based (from large chat corpus)
 - Information Retrieval
 - Neural network encoder-decoder

Chatbots

- Sometimes for fun
- Originally designed as a testbed for clinical therapy

Eliza: Weizenbaum (1966)

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

Domain: Rogerian psychology interview

Draw the patient out by reflecting patient's statements back at them

Rare type of conversation in which one can “assume the pose of knowing almost nothing of the real world”

Patient: "I went for a long boat ride"

Psychiatrist: "Tell me about boats"

- You don't assume she didn't know what a boat is
- You assume she had some conversational goal
- Most chatbots trying to pass Turing test choose a domain with similar properties

Eliza pattern/transform rules

(0 YOU 0 ME) [*pattern*]

→

(WHAT MAKES YOU THINK I 3 YOU) [*transform*]

You hate me

WHAT MAKES YOU THINK I HATE YOU

0 means kleene *

The 3 is the constituent # in pattern

Eliza Rules

keyword **pattern** **Ranked list of transforms**

**If it does not, then an empty list is
Placed in KEY(i), and the key list str
placed on that list. If KEY(i) already c
, then the name of the key list structure**

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

Keywords are ranked from specific to general

I know everybody laughed at me

- “I” is a very general keyword:

I: (I *) -> (You say you 2)

YOU SAY YOU KNOW EVERYBODY LAUGHED AT YOU

- “Everybody” is much more interesting (someone using universals like everybody/always is probably “referring to some quite specific event or person”)

WHO IN PARTICULAR ARE YOU THINKING OF?

- Implementation: keywords stored with their rank

Everybody 5 (*transformation rules*)

I 0 (*transformation rules*)

NONE

PLEASE GO ON
THAT'S VERY INTERESTING
I SEE

Memory

```
(MEMORY MY  
  (0 YOUR 0 = LETS DISCUSS FURTHER WHY YOUR 3)  
  (0 YOUR 0 = EARLIER YOU SAID YOUR 3)
```

- Whenever “MY” is highest keyword
 - Randomly select a transform on the MEMORY list
 - Apply to sentence
 - Store on a stack
- Later, if no keyword matches a sentence
 - Return the top of the MEMORY queue instead
- [Fun fact: this queue is the earliest hierarchical model of discourse]

Other Eliza stuff

- Rules can refer to classes of words
 - Family = mother, father, brother, sister
 - NOUN = ...
- Don't reuse transforms in the same conversation
 - Whenever we use a transform associated with a pattern
 - We increment a counter for that rule
 - So the next time we use the next ranked transform
- Some basic transforms happen during input processing
 - I -> YOU
 - YOU -> I

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 implications
 - Suggesting that they were having quite private conversations with ELIZA
- Anthropomorphism and the Heider-Simmel Illusion
 - <https://www.youtube.com/watch?v=8FIEZXMUM2I>

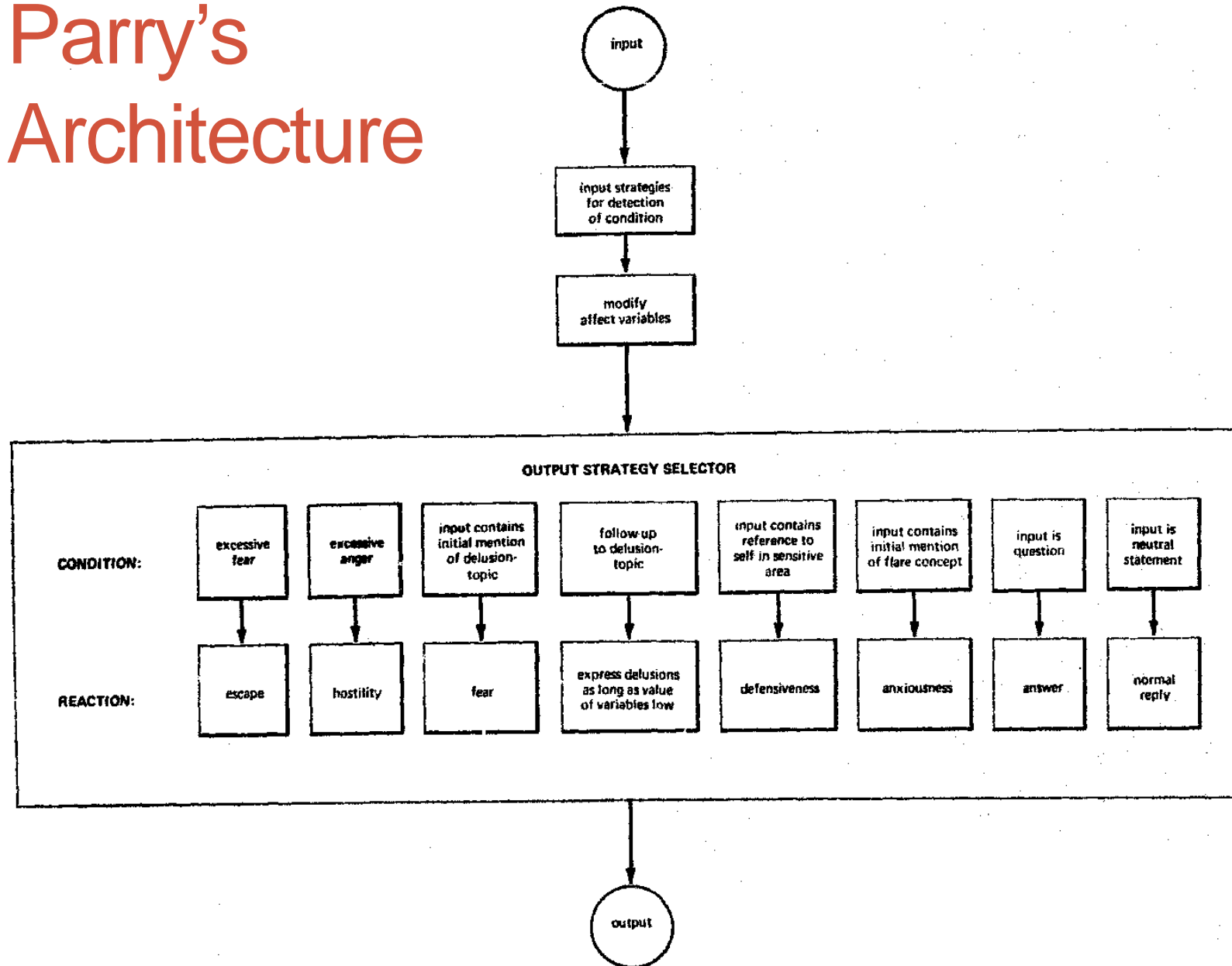
Parry

- Colby 1971 at Stanford
- 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'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



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

Flare concepts

- List of concepts related to Mafia
- An ordered graph designed to lead interviewer to topic
horses→
horseracing→gambling→bookies→underworld→Mafia
- The mention of a new flare topic by interviewer causes a rise in Fear
- Flare topics cause Parry to give preset responses to that flare

Each sentence is mapped into a conceptualization

- A predication on a conceptual object
- A predication on a relation between two objects
- A predication on an attribute:

What is your work?

What sort of work do you do?

Where do you work? → (your work?)

What do you do for a living?

What is your job?

Do you have a job?

What is your occupation

- Complex Pattern/transform rules
 - Different predicates (fear, afraid of)
 - Ordering (You are afraid of me = I frighten you)

Detecting Other's Intent

$\langle \text{OTHER'S INTENTION} \rangle \leftarrow \langle \text{MALEVOLENCE} \rangle \mid \langle \text{BENEVOLENCE} \rangle \mid \langle \text{NEUTRAL} \rangle$

MALEVOLENCE-DETECTION RULES

1. $\langle \text{malevolence} \rangle \leftarrow \langle \text{mental harm} \rangle \mid \langle \text{physical threat} \rangle$
2. $\langle \text{mental harm} \rangle \leftarrow \langle \text{humiliation} \rangle \mid \langle \text{subjugation} \rangle$
3. $\langle \text{physical threat} \rangle \leftarrow \langle \text{direct attack} \rangle \mid \langle \text{induced attack} \rangle$
4. $\langle \text{humiliation} \rangle \leftarrow \langle \text{explicit insult} \rangle \mid \langle \text{implicit insult} \rangle$
5. $\langle \text{subjugation} \rangle \leftarrow \langle \text{constraint} \rangle \mid \langle \text{coercive treatment} \rangle$
6. $\langle \text{direct attack} \rangle \leftarrow \text{CONCEPTUALIZATIONS} ([\text{you get electric shock}], [\text{are you afraid mafia kill you?}])$
7. $\langle \text{induced attack} \rangle \leftarrow \text{CONCEPTUALIZATIONS} ([\text{I tell mafia you}], [\text{does mafia know you are in hospital?}])$
8. $\langle \text{explicit insult} \rangle \leftarrow \text{CONCEPTUALIZATIONS} ([\text{you are hostile}], [\text{you are mentally ill?}])$
9. $\langle \text{implicit insult} \rangle \leftarrow \text{CONCEPTUALIZATIONS} ([\text{tell me your sexlife}], [\text{are you sure?}])$
10. $\langle \text{constraint} \rangle \leftarrow \text{CONCEPTUALIZATIONS} ([\text{you stay in hospital}], [\text{you belong on locked ward}])$
11. $\langle \text{coercive treatment} \rangle \leftarrow \text{CONCEPTUALIZATIONS} ([\text{I hypnotize you}], [\text{you need tranquilizers}])$

Detecting Other's Intent

$\langle \text{OTHER'S INTENTION} \rangle \leftarrow \langle \text{MALEVOLENCE} \rangle \mid \langle \text{BENEVOLENCE} \rangle \mid \langle \text{NEUTRAL} \rangle$

BENEVOLENCE-DETECTION RULES

1. $\langle \text{benevolence} \rangle \leftarrow \langle \text{positive attitude} \rangle \mid \langle \text{positive story attitude} \rangle$
2. $\langle \text{positive attitude} \rangle \leftarrow \text{CONCEPTUALIZATIONS} ([\text{I want help you}], [\text{you understand me}])$
3. $\langle \text{positive story attitude} \rangle \leftarrow \langle \text{story interest} \mid \langle \text{story agreement} \rangle$
4. $\langle \text{story interest} \rangle \leftarrow \langle \text{topic comment} \rangle \mid \langle \text{topic question} \rangle$
5. $\langle \text{topic comment} \rangle \leftarrow \text{CONCEPTUALIZATION} ([\text{bookies are not reliable}])$
6. $\langle \text{topic question} \rangle \leftarrow \text{CONCEPTUALIZATION} ([\text{what did you do to bookie?}])$
7. $\langle \text{story agreement} \rangle \leftarrow \text{CONCEPTUALIZATIONS} ([\text{I believe you}], [\text{you are right}])$

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]

(9) What trouble did you have with the police

COPS DON'T DO THEIR JOB. *['police' acts as a flare]*

(10) What do they do instead?

COPS ARREST THE WRONG PEOPLE.

(11) They arrest the right ones sometimes

THE LAW SHOULD GET THOSE ITALIAN CROOKS.

(12) Do you know any Italian crooks?

I TRY TO AVOID THE UNDERWORLD.

(13) Are you afraid of the underworld?

THE MAFIA ARE THE WORST GANGSTERS.

(15) Are you connected with the Mafia?

YOU KNOW, THEY KNOW ME.

(16) How do they know you?

THEY SPY ON ME.

(20) ARE YOU SURE OF ALL THIS ?

YOU DON'T BELIEVE ME ? *[FEAR, ANGER, MISTRUST GO UP]*

When fear is high, the model won't discuss its beliefs

(1) Is the law after you?

THE LAW SHOULD GET THOSE ITALIAN CROOKS.

(2) Do you mean the Mafia?

LET'S TALK ABOUT SOMETHING ELSE.

(3) Are you afraid of the Mafia

I'D RATHER NOT DISCUSS IT.

[Fear is too high so Parry won't talk about 'Mafia'.]

(4) Perhaps you are paranoid about them?

YOU WANT TO KEEP ME IN THE HOSPITAL.

(The model interprets being called 'paranoid' as an insult and as an intent to control, so ANGER & FEAR rise)

Eliza Meets Parry

Vincent Cert, RFC439

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 its 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

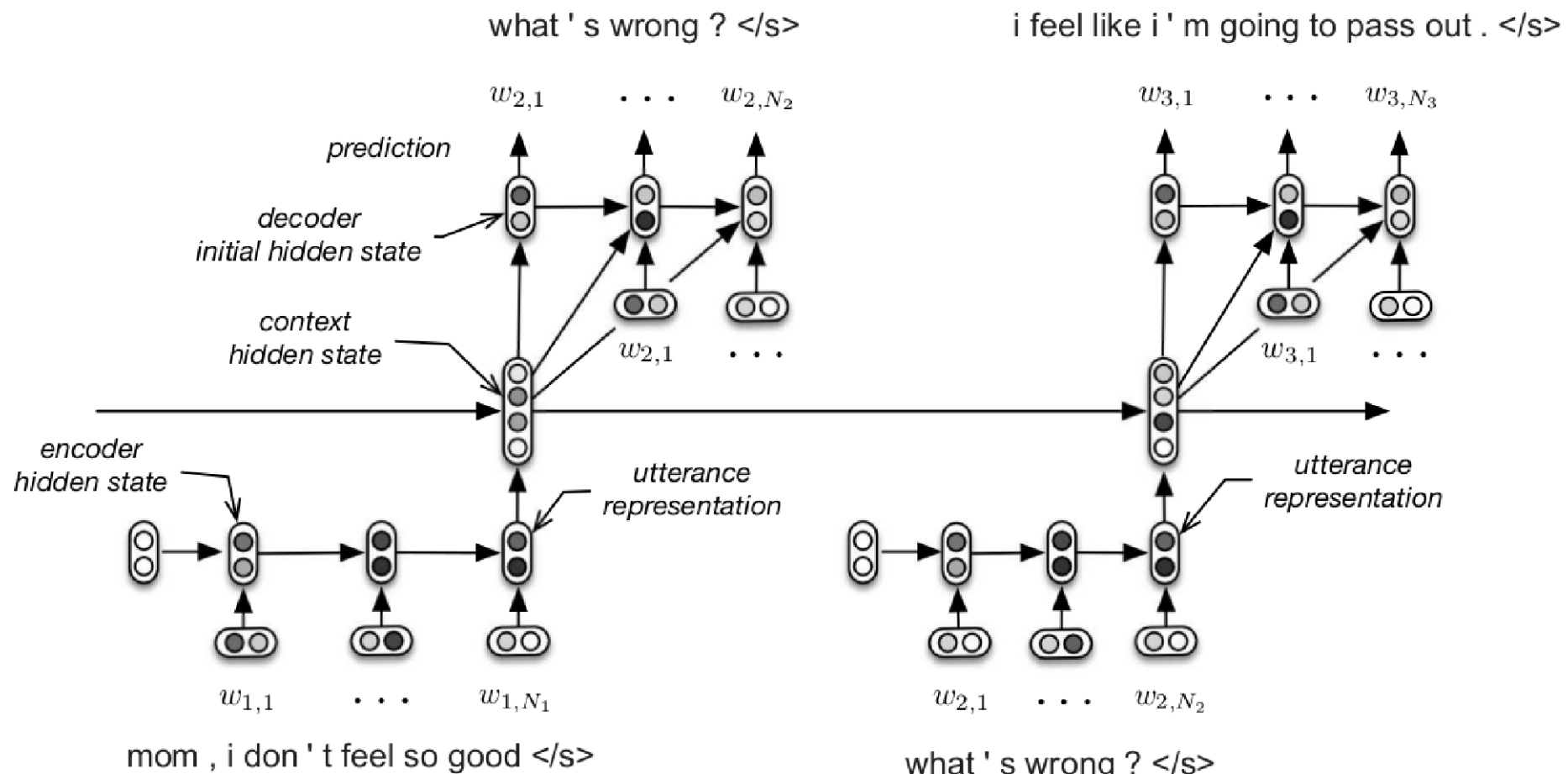
- Cleverbot
- Xiaoice
- Mine conversations of human chats or human-machine chats
- Choose a response by
 - Taking user's turn and finding a (tf-idf) similar turn in the dataset
 - Grabbing whatever the response was to that turn.

Deep-learning chatbots

- Train on:
 - movie dialogue databases
 - twitter conversations
- Train a deep neural net to map from one users turn to the other users response

Seq2seq model architecture

Serban, Iulian V., Alessandro Sordoni, Yoshua Bengio, Aaron Courville, and Joelle Pineau. 2015. "Building End-To-End Dialogue Systems Using Generative Hierarchical Neural Network Models."



Sample outputs from a neural net chatbot

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

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!!

Sample output from a neural net chatbot

Sordoni A, Galley M, Auli M, Brockett C, Ji Y, Mitchell M, Nie JY, Gao J, Dolan B. A neural network approach to context-sensitive generation of conversational responses. NAACL

trained on 127M Twitter context-message-response triples

#	Context c	Message m	Generated Response r
1	noone can help this time its just i need a support system	well im here to support you. whenever you need me.	thank you, i appreciate it thank you
2	nothin much, and how's the book?!	its good but i'm only like halfway through cuz i don't feel like reading. i'm so bored ...	that's good! i have the book but i'm bored too.
3	i know! what have you been up to?	nothing really. just enjoying summer and working. what about you?	that's good! nothing much just listening to music and you?
4	thanks, your way better though	i'm just good at expressing it that's but trust me you are freakin amazing and waay better	i know, i don't trust you, i love you too! thank you
5	thanks. yeah i am good thanks! good, but angry!	sorry you're angry, been there, i hope it dies down.	i hope so too, i'm not angry!!
6	figures. bass. never ate bass.	bass is extremely mild with very few bones. my favorite after catfish	that's one of the bones, chuck bass is mine too.
7	today i will walk for miles. clear sky clear mind.	love walking. it's too hot to walk this month. i haven't moved. frozen. heat freeze.	it's too hot for you to get up to honey if you have frozen yogurt to you.
8	arresting people over "nasty tweets"? please. i'm not condoning what the lad did but arresting him is a tad silly.	it appears he may have sent death threats to others while all this was kicking off too.	i did! he was armed with nuclear threats? that's what's happening to you.

Summary

- State of the art:
 - Frame-based systems:
 - hand-written rules for slot fillers
 - statistical classifiers to fill slots
 - Chatbots:
 - Simple rule-based systems
 - IR or Neural networks: mine datasets of conversations.
- What's the future?
 - More use of data
 - Problems:
 - Acquiring that data
 - Key direction: Integrating goal-based and chatbot-based systems

Appendix

- Appendix