Whats it Mean?

NLP beyond syntax

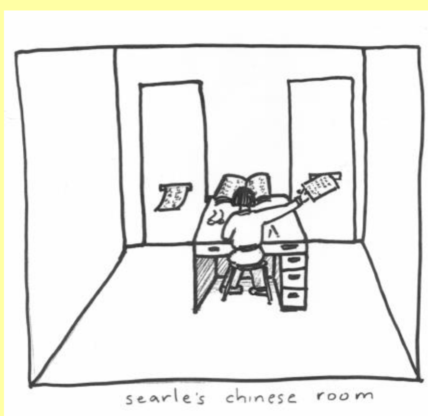
What is a good representation for information contained in language, in sentences, stories, books?

- The .WAV or DOC file?
- The sequence of letters or words?
- syntactic parse trees?
- the First-order Predicate Calculus (logical) translation?
- How could we represent and reason about content of utterances?
  - Is there an equivalent "canonical form" for language representations as there are for puzzle and game positions?

Searle's Chinese Room Argument against AI

- An operator O. sits in a room; Chinese symbols come in which O. does not understand. He has explicit instructions (a program!) in English in how to get an output stream of Chinese characters from all this, so as to generate “answers” from “questions”. But of course he understands nothing even though Chinese speakers who see the output find it correct and indistinguishable from the real thing.

Does he understand chinese?



Limits of Syntactic parsing

- A well developed art, with clear data structures and well-developed polynomial time algorithms, but
  - What do you use a parse tree for?
    - Syntax is ambiguous
  - how do you integrate with lexical access and semantics?
    - What good is a Parse Tree?

Syntax is ambiguous

- Multiple parse trees for simple constructions
- Same Parse Trees for Completely different uses
  - MARY ATE SPAGHETTI WITH MEAT SAUCE
  - MARY ATE SPAGHETTI WITH JOHN
  - MARY ATE SPAGHETTI WITH CHOPSTICKS

Syntax is not enough!

- What do you use a parse tree for, anyhow?
  - [S [NP [NOM MARY]]
  - [VP [V ATE][NP [N SPAGHETTI]
  - [PP [PREP WITH]
  - [NP [ADJ MEAT][N SAUCE]]]
  - [S [NP [NOM MARY]]
  - [VP [V ATE][NP [N SPAGHETTI]]
  - [PP [PREP WITH] [NP [NOM JOHN]]]]
  - [S [NP [NOM MARY]] [VP [V ATE]
  - [NP [N SPAGHETTI]]
  - [PP [PREP WITH] [NP [N CHOPSTICKS]]]]

Problem of Ambiguity: Rampant at all levels

- Same sequence can mean multiple things
  - John took her flowers
  - John took her money
  - Trust Shrinks
  - John shot some bucks
  - I saw the Grand Canyon Flying to New York
- Different sequences can mean the same thing

Anaphora & Reference

- Use of pronouns and ellipsis in dialog and multiple sentences:
  - John shot Bill. He was dead and he felt guilty
  - What kind of ice cream do you want? I think vanilla.
  - John's grandfather was ill. The old man had gallstones.

Missing Information

- The balloon went into a tree. The balloon burst. The baby cried. Mary gave John a mad look and picked up the baby.
- Lots of Inferences:
  - Balloon was filled up
  - Baby liked Balloon
  - Tree burst Balloon
  - John was responsible
  - Baby cried over Balloon
  - Mary picks up baby to soothe it...

Problem of Non-literal language

- Idioms
  - John kicked the bucket
- Metaphor and Analogy
  - Her hair was like lambswool, her teeth were like pearls (soft and white, not white and hard)
  - The editor died on me today
  - The engine ate up the track

Problems of Novelty and Openness

- Once you make up a lexicon and rules, they change:
  - I'll fax/pdf/text it to you (new verbs)
  - Lets hit stackoverflow and drink some java.
  - Trump is WillieHortonizing the immigration issue
  - Covfefe?

Curious Phenomena easy for computers, hard for humans

- Garden Path Sentences
  - The prime number few
  - The horse raced past the barn fell
  - the cotton clothing is made of grows in Mississippi
  - Norman weighed 240 pounds… of bananas

Semantic Processing

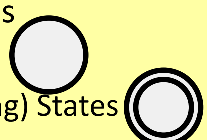
- Internal representation for meaning which
  - is canonical across languages
  - deep
  - provides easy ability to do inferences
  - e.g. Case-filler structures
    - (Event: A meal)
    - (actor: Mary)
    - (location: unknown)
    - (object: spaghetti)
    - (Instrument: Chopsticks)

Semantic Grammars

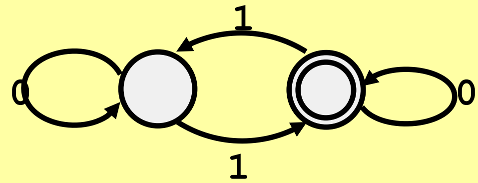
- Use phrase structure, but orient not towards grouping structure, but towards use
  - Instead of parsing to NP's and VP's of linguistic theory, parse to agents, objects, other elements of domain of discourse
- Inspired by early NLP interfaces to databases
  - Lunar (Woods, 1970)
  - PLANES (Waltz 1975)
- often implemented with ATN's

Simple Transition networks are Finite State Machines

- nodes are states
  - Start State
  - Final (accepting) States

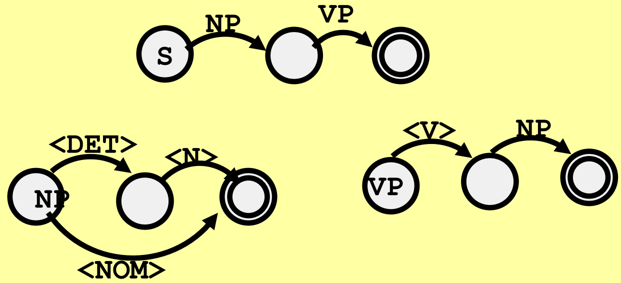


- links signify tokens
- Recognizes Regular languages (no parentheses) like odd parity



Recursive Transition Networks

- allow subnets on links
- Capable of recognizing CF



Augmented Transition networks

- By adding Memory to the network in the form of "registers" and adding data-structure manipulation to link procedures, ATN's are a universal programming language
- Actions on Links
  - Test membership in lexical category
  - "Push" to another network
  - Set and read registers
  - Backtracking search is controlled by success and failure of tests and network structure

Sample semantic grammar

- Example domain—access to DB of US Navy ships
- S : <present> the <attribute> of <ship>
- <present>: what is | [can you] tell me
- <attribute>: length | beam | class
- <ship>:the <shipname>
- <shipname>: kennedy | enterprise
- <ship>: <classname> class ship
- <classname>: kitty hawk | lafayette
- Example inputs recognized by above grammar:
- what is the length of the Kennedy
- can you tell me the class of the Enterprise
- what is the length of Kitty Hawk class ships

Semantic Grammars

- Advantages
  - result can be used when parse is complete, i.e. no need to deal with semantic interpretation of syntax
  - Avoids syntactic ambiguities
  - allows for noisy syntactic input (i.e. ungrammatical but meaningful)
- Problems
  - scale-up: as more rules are added, negative interaction increase
  - failure to handle syntactic generalizations

Case Grammars

- In sentences, common syntactic constructions indicate different roles for objects and actions
- Subjects can be Agents or Instruments, for example
  - THE MAN BROKE THE WINDOW
  - THE HAMMER BROKE THE WINDOW
- Passivization and other transformations often switch order of roles
  - The window was broken by the hammer

Case Grammar (Fillmore)

- There are many different case roles associated with verbs
- Some cases are universal, others are particular to certain verbs.
- When the internal representation for an action is a frame structure, the cases correspond to the slots

- A Agent Instigator
- I Instrument
- O Objective (direct object)
- Factive
- L Locative Where it took place
- S Source where the action started
- G Goal Where it ends
- T Time

Parsing with Case Grammar

- Verbs have preferences and default logics for certain types of case structures, and certain kinds of surface words help constrain case filling:
  - a transitive verb wants an object
  - hit, Instrument defaults to agent's hand
  - give takes both object and beneficiary
  - "at the ..." usually indicates Locative
- Parsing is expectation driven, locate the verb, figure out how to account for the surrounding context as different cases.
    - Each event would construct a frame with case slots and fillers

Semantic Primitives

- Rather than each verb or action having a frame with its own set of case roles, one can organize systems in which verbs are organized into hierarchies where the same representations and same inferences can be drawn.
- Eat, drink breathe, feast, hyperventilate, etc are all instances of INGEST, with preferences for different kinds of objects, speeds, etc.
- Instead of repeating knowledge for each verb, store knowledge with a prototype semantic primitive.

Schank's Canonical Form:

Conceptual Dependency (CD)

- Developed as a basis for NLP work on reading, summarizing, translating, representing events in stories. Reduced 500 verbs to around 11 generalized actions

- goal: "interlingua" representation
- One way to represent many different ways to say same thing
- Place to attach AI inference engine

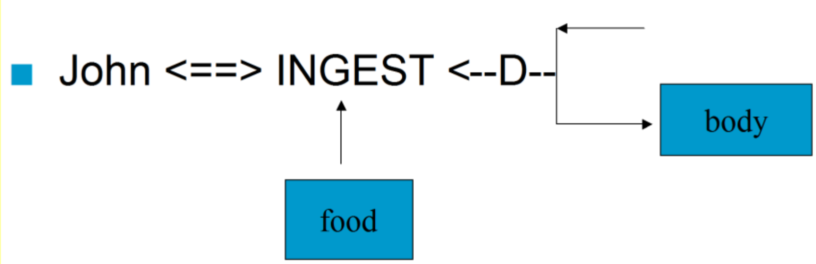
The primitive ACT's of CD

- ATRANS: Transfer of an abstract relationship (e.g. give)
- PTRANS: Transfer of the physical location of an object (e.g. go)
- PROPEL: Application of physical force to an object (e.g. push)
- MOVE: Movement of a body part by its owner (e.g. kick)
- GRASP: Grasping of an object by an actor (e.g. clutch)
- INGEST: Ingestion of an object by an animal (e.g. eat)

More Primitives

- EXPEL: Expulsion of something from the body of an animal (e.g. cry)
- MTRANS: Transfer of mental information (e.g. tell)
- MBUILD: Building new information out of old (e.g. decide)
- SPEAK: Production of sounds (e.g. say)
- ATTEND: Focusing of a sense organ towards a stimulus (e.g. listen)

Example: John Ate



CD and Scripts

- CD representations could represent many kinds of events in an almost canonical way
- Inferences could be organized around the primitives, rather than around every work
- To recognize stories, Schank developed SCRIPTS, which were program like sequences of CD's with variables.
- Scripts allowed programs to fill in missing information in stereotypical stories.

Scripts

A Schankian script is a series Of CD's with linked variables.

A body of scripts is used to match against a set of stories, filling expectations in artificial readers.

Script: ROBBERY *Track: Successful Snatch*

Props:
G = Gun,
L = Loot,
B= Bag,
C = Get away car.

Roles:
R = Robber,
M = Cashier,
O = Bank Manager,
P = Policeman.

Entry Conditions:
R is poor.
R is destitute.

Results:
R has more money.
O is angry.
M is in a state of shock.
P is shot.

Scene 1: Getting a gun

R PTRANS R into Gun Shop
R MBUILD R choice of G
R MTRANS choice.
R ATRANS buys G

(go to scene 2)

Scene 2 Holding up the bank

R PTRANS R into bank
R ATTEND eyes M, O and P
R MOVE R to M position
R GRASP G
R MOVE G to point to M
R MTRANS "Give me the money or ELSE" to M
P MTRANS "Hold it Hands Up" to R
R PROPEL shoots G
P INGEST bullet from G
M ATRANS L to M
M ATRANS L puts in bag, B
M PTRANS exit
O ATRANS raises the alarm

(go to scene 3)

Scene 3: The getaway

M PTRANS C

Schankian NLP

- Through the 1970's Roger Schank and students produced an impressive set of works using heuristic programs based on semantic distinctions

- MARGIE
  - Read sentences and made many inferences
- SAM -Script Applying Mechanism
  - used event schema to organize knowledge of newspaper reports on auto accidents. Read, summarized, answered questions, and translated

Schankian NLP

- PAM- Plan applier Mechanism
  - Used knowledge of people's PLANS to understand more dynamic scripts
- FRUMP- Fast Reading Understanding Mem.
  - Hooked up to the AP wire, summarized
- CYRUS - Computerized Yale
  - Simulation of Cyrus Vance's Knowledge, beginning of CBR revolution
- Boris- Better Organized Reading &Inference
  - Biggest NLP program ever, used 22 different knowledge structures and understood morality tales.

Every Commercial Success is hailed as "The" dawn of AI

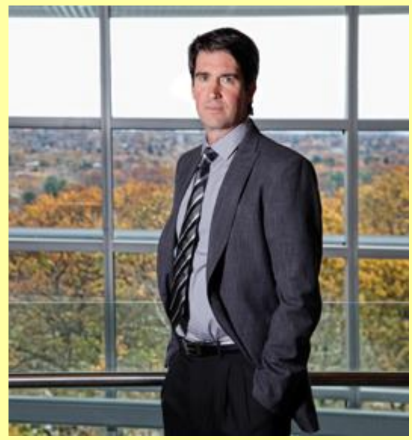
Siri, a Virtual Personal Assistant

Bringing Intelligence to the Interface

Tom Gruber
CTO & cofounder, **Siri**

Adam Cheyer COSI BS '88

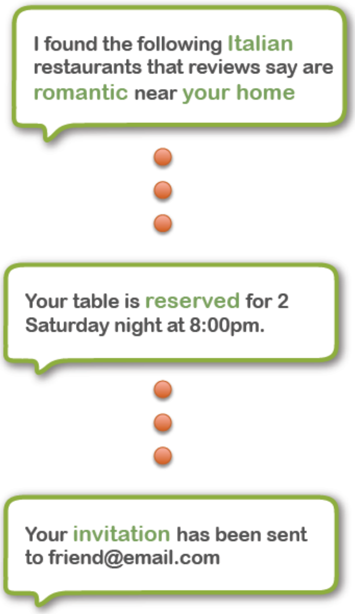
- co-founder and VP Engineering SIRI
- Change.org



A Virtual Personal Assistant:

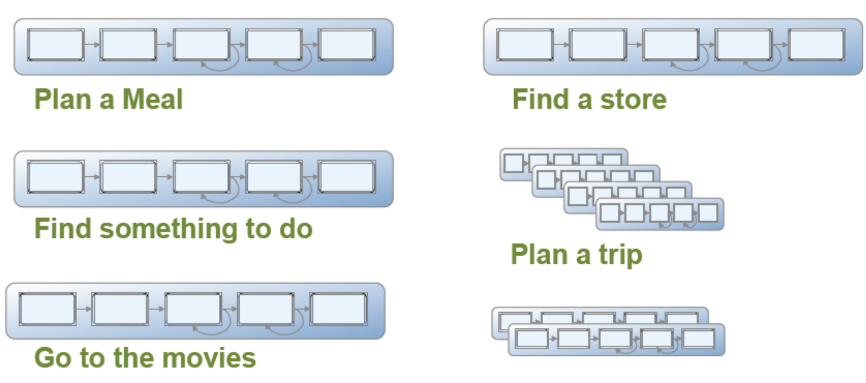
- **Does Things for You**
  focus on task completion
- **Gets What you Say**
  intent understanding via conversation
- **Gets to Know You**
  learns and applies personal information

Siri Helping you Do Things



- Multiple-criteria vertical search and browse
- combining multiple sources of information
- with integrated transactions
- and social communication

And Lots of Tasks



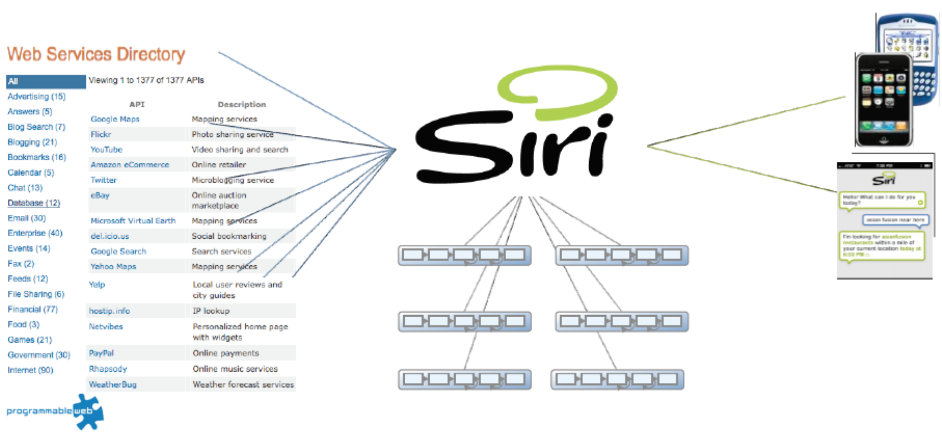
Employing the services of...

OpenTable
GAYOT.com
BOSS
YAHOO! LOCAL
yelp
localeze
allmenus

Contacts
Email
Maps

and many more...

Service Delegation: The Mother of All Mash-ups



Web Services and APIs | **Domain & Task Models** | **Guided Dialog**

Virtual Assistant Evolution

Doing Things For You

Service APIs | Data feeds | Auth Standards | SW & Data Commons

Faceted Search Domains | Recommendation Services

Getting What You Say

Location | Speech | Semantic NLP | Linguistic NLP

Date/time | Conversational UI | Social Contexts

Getting Personal

Contacts | Calendars | Explicit Preferences

Profile | Favorites | Learned Preferences

Today → Tomorrow → Future

NLP Summary

- We didnt talk about Dialog, speech acts, etc
  - Can you pass the salt? Yes I can...
- Current State of Theory and Practice
  - Oscillation between isolating general knowledge of language, and leaving everything in the Lexicon
  - Military funding started organizing for "broad coverage" rather than theoretical purity, and much current work is in shallow/statistical ML rather than deep symbolic forms of NLP

the era of "deep" learning

- large and deep complex neural architectures
- extensive training sets
- millions of dollars in CPU and GPU Time
- surprisingly effective at certain tasks

Transformer Networks

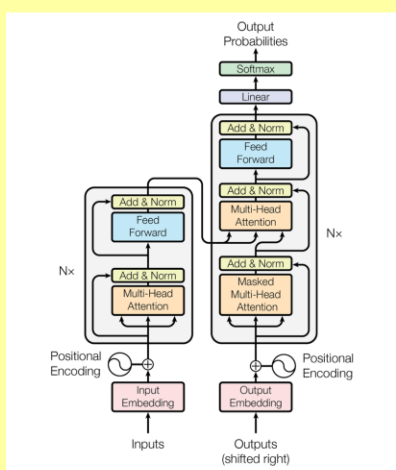


Figure 1: The Transformer - model architecture.

GPT3

- 175 billion weights, hundreds billions words
- feed it a prompt and it keeps going generating English.

- **Below is a screenplay for a film-noir hard boiled detective story by Raymond Chandler about the boy wizard Harry Potter:**
- **“Harry Potter”**
  By Raymond Chandler
- Harry Potter, Private Eye.
  Scene: A small dingy office, early morning, furniture of the Salvation Army store variety. Sordid atmosphere. Harry Potter, in ratty tweed suit, unpressed shirt, and unshined shoes, sits behind the desk looking haggard, rumpled, and embittered. In one corner of the office a torn shade rattles at the wind gusts outside. Harry has one long index finger on the butt of a .38 and he broods over a photograph. The photograph shows a gorgeous blonde wearing an evening gown. She is holding a cocktail in one hand and looking pensively at a cigarette in the other. A tear adorns her cheek. Harry looks at her for a long moment, sighs, then puts his gun down and stands. He straightens his clothes, scratches his head, then with more resolution turns around, picks up his pistol, and leaves the office. He passes through the front room and looks out the dirty window. An old woman is washing the sidewalk outside with a mop. A young man in a double breasted gray suit is leaning against the building. Harry sighs again and goes out the door. He walks up to the young man and without ceremony punches him in the jaw.