CS 140/240: Artificial Intelligence
Prof. Marilyn A. Walker
Course Summary

- What is Artificial Intelligence?
- How do we achieve it?
  - Knowledge Representation
  - Planning and Reasoning
  - Language Processing & Dialogue
- How do we evaluate it?
- Applications & Research
Who am I?

- Google “Marilyn Walker”
- Google Scholar “Marilyn Walker”
- users.soe.ucsc.edu/~maw
- nldsp.soe.ucsc.edu
Go there.
Also has links to readings
Still being updated for new readings different from last year

http://www.soe.ucsc.edu/classes/cmps140/Winter11/
Teaching Method

- Lectures M-W evening 19.00 – 20.45, Thimann I
- Course Texts
  - Natural Language Processing in Python.
- CS 240 students separate lab and reading/discussion of research papers. Plus oral presentations to CS 140 students on subset of research papers
- Project: Each project has 1 CS 240 student who directs/manages project and has differential responsibilities (and grading) and 4 CS 140 students
So: What is AI?
What is AI?

- The use of computer programs and programming techniques to cast light on the principles of intelligence in general and human thought in particular (Boden)
- The study of intelligence independent of its embodiment in humans, animals or machines (McCarthy)
- The study of how to do things which at the moment people do better (Rich & Knight)
- The science of making machines do things that would require intelligence if done by men. (Minsky)
- Automating commonsense activities everyone can do (chess?) (Papert)
AI is nearly as old as computing.

- 1941 Konrad Zuse, Germany, general purpose computer
- 1943 McCulloch & Pitts: “A logical calculus of the ideas immanent in nervous activity”
- 1943 Britain (Turing and others) Collossus, for decoding
- 1945 ENIAC, University of Pennsylvania (women programmers!)
- 1950 “Computing Machinery and Intelligence”, A.M. Turing introduced “The Turing Test”.
- 1956 The Logic Theorist Program. Newell, Shaw and Simon
- 1956 Dartmouth Conference: The term Artificial Intelligence coined at Dartmouth---intended as a two month, ten person study!
Different Views of What AI is About

- **Cognitive Scientists (the bird people):** those who think AI is the only serious way of finding out how WE work (since opening heads doesn’t yet tell you much)
- **Engineers (the airplane people):** those who want computers to do very smart things, quite independently of how WE work
- **Philosophers:** Can machines think? What is consciousness?
But everyone agrees that AI involves representing knowledge about the world and how to do things.
Human Knowledge is Represented in Language

- Newspapers (*Print but now online*)
- Scientific Articles (*Print but now online*)
- Books (*Print but now online*)
- Penn Treebank: a million words of parsed and semantically labelled news, books etc.
- Dictionaries and Thesauri (*Print but now Wordnet & Freebase*)
- Encyclopedias (*Print but now Wikipedia*)
Who mocked Blair?

Powerset Results

1. International Moron Patrol
   - It contains political references, often mocking Tony Blair and George W. Bush, other superhero cameos (such as cameos from the Justice League and Superman in episode 28) and even characters from Disney (a notable one is Winnie the Pooh, who is actually made out to be pure evil in this series, something of a mockery).

2. Ken Livingstone
   - William Hague, then Leader of the Opposition taunted Blair at Prime Minister's Question Time: "Why not split the job in two, with Frank Dobson as your day mayor and Ken Livingstone as your nightmare?"

3. The Facts of Life (TV series)
   - Comedy Central's_Drawn Together parodies Blair and her cousin Geri in an episode entitled "The Other Cousin".

The Other Guys

1. Yo, Blair - Wikipedia, the free encyclopedia
   - Yo, Blair! is the title of a polemical 2006 book by Geoffrey Wheatcroft. Yo, Blair! is actually made out to be pure evil in this series, something of a mockery.

2. Criticism of Tony Blair - Wikipedia, the free encyclopedia
   - The criticism of Tony Blair includes accusations of dishonesty and authoritarianism as well as Blair mocked as U.S. poodle. Reuters UK 18 July 2006...

3. Get tough on crime - Wikipedia, the free encyclopedia
   - The speech also marked Blair as one of the coming men of the Party. The slogan would later go on to be mocked when crime continued to be rampant.
The Problem with Natural Language

- Ambiguous
  - “I know more intelligent people than him.”
  - “I saw the Grand Canyon flying to New York.”/”I saw a 747 flying to New York.”

- Might depend on information outside of text channel
  - “He drove to the white house.”/”He drove to the White House.”

- Syntax, vocabulary and word meaning change over time

- So we need a formal way of representing the knowledge usually represented in language
Two schools of thought in AI for the last 50 years

- Symbolic: represent knowledge using logic and rules that define inference procedures on logic
- Statistical: represent knowledge as probabilities based on observations of the world
- Both of these traditions had their roots in the same paper: McCulloch and Pitts 1943
McCulloch and Pitts 1943

- “A Logical Calculus of the Ideas Immanent in Nervous Activity”
- Seminal paper for AI
- Simple model of neuron
- Also influenced the design of the first computers
- Starts with the Logical calculus =>
  - ideas from logic at the time, Carnap, Russell and Whitehead.
Propositional Logic Calculus

- The symbols of propositional logic are:
  - P, Q, R, S
  - These can stand for any statement. E.g. “it is raining”, “I am at work”
- The truth symbols, true, false
- The connectives: AND, OR, NOT, IMPLIES, EQUALS
Propositional Logic Sentences

- True, False, P, Q, R are sentences.
- The negation of a sentence is a sentence NOT P ("it is not raining").
- The conjunction of two sentences is a sentence, P AND Q ("it is raining and I am at work").
- P, Q are called the conjuncts.
- The disjunction of two sentences is a sentence, P OR Q ("it is raining or I am at work").
- P, Q are called the disjuncts.
Propositional Logic Sentences

- The implication of one sentence from another, $P \text{ IMPLIES } Q$ (“it is sunny implies I am outdoors”)
- $P$ is called the premise/antecedent and $Q$ is called the conclusion/consequent
- The equivalence of two sentences is a sentence, $P \text{ OR } Q \text{ EQUALS } R$
- Legal sentences are also called well-formed formulae
\((P \land Q) \implies R\) \text{ equals } \neg P \lor \neg Q \lor R

- Is well-formed:
  - P, Q, R are propositions
  - P AND Q is a sentence
  - \((P \land Q) \implies R\) is a sentence
  - NOT P, NOT Q are sentences
  - NOT P OR NOT Q is a sentence
  - NOT P OR NOT Q OR R is a sentence
  - \((P \land Q) \implies R\) \text{ equals } NOT P OR NOT Q OR R
Propositional Logic Semantics

- An interpretation is a mapping from the propositional symbols into the set T, F
  - The symbol true is always assigned T
  - The symbol false is always assigned F
- \( \neg P \) is T when \( P \) is F and vice versa
- The truth assignment of AND is T only when both conjuncts have the value
- ETC (will cover in chap 7 and more)
So what does this have to do with the brain?
The Human Brain

- Contains approximately ten thousand million basic units, called neurons.
- Each neuron is connected to many others.
- Neuron is basic unit of the brain.
- Neurons specialize in communication
  - Information passes among neurons that result in brain activity
The Neuron

- **Soma** is the body of neuron
- Attached to soma are long filaments: **dendrites**.
- Dendrites act as connections through which all the inputs to the neuron arrive.
- **Axons** serve as output channel
Activating a neuron

- Axon: electrically active. Serves as output channel of neuron.
- Axon is non-linear threshold device. Produces pulse, called action potential when resting potential within the soma rises above some threshold level.
- Axon terminates in synapse which couples axon with dendrite of another cell.
- No direct linkage, temporary chemical one. Synapse releases neurotransmitters which chemically activate gates on dendrites.
- Activating gates, when open allow charged ions to flow. These charged ions alters the dendritic potential and provides a voltage pulse on the dendrite which is conducted to next neuron body/soma.
- A single neuron will have many synaptic inputs on its dendrites, and may have many synaptic outputs connecting it to other cells.
How a neuron processes input

- **Excitatory input**
  - Neurotransmitter increases membrane potential

- **Inhibitory input**
  - Neurotransmitter decreases membrane potential

- **Temporal summation**
  - Initial input not sufficient to trigger action potential, but 2nd input, following within a short time, can

- **Spatial summation**
  - Several inputs (excitatory or inhibitory) originating from different neurons can have cumulative effect
Important features to model

- Only basic details of neurons really understood.
- Neuron accepts many inputs, which are all added up (in some fashion).
- If enough active inputs received at once, neuron will be activated, and fire. If not, remains in inactive quiet state.
- A stand-alone analogue: logic gate.
Important Features of the Brain to Model

- The human brain: poorly understood, but capable of immensely impressive tasks.
- *Fault tolerant*
  - Distributed processing
  - Many simple processing elements sharing each job
  - Can tolerate some faults without producing errors
- *Graceful degradation*
  - with continual damage, performance gradually falls from high level to reduced level
  - Only catastrophic failure (e.g., death) results in zero performance
Modelling single neuron

Important features to model

- The output from a neuron is either on or off
- The output depends only on the inputs. A certain number must be on at any one time in order to make the neuron fire.

The efficiency of the synapses at coupling the incoming signal into the cell body can be modelled by having a multiplicative factor (i.e. weights) on each of the inputs to the neuron.

More efficient synapse has correspondingly larger weight.
McCulloch Pitts Neuron

INPUT X1
  W1

INPUT X2
  W2

INPUT Xn
  Wn

Threshold unit
Does weighted sum of inputs pass threshold?

OUTPUT

Total input = weight on line 1 x input on 1 + weight on line 2 x input on 2 + weight on line n x input on n (for all n)

Basic model: performs weighted sum of inputs, compares this to internal threshold level, and turns on if this level exceeded.
Modelling the neuron

- McCulloch and Pitts proposed this model of neuron in 1943.
- Model of neuron, not a copy: does not have complex patterns and timings of actual nervous activity in real neural systems.
- Because it is simplified, can implement on digital computer (Logic gates and neural nets)
- Influenced Von Neumann’s design of the first computer
- Remember: it is only one model of the brain! (some smart devices now in biological strata, cell computing)
Truth Table for *And* *(using 0 and 1)*

<table>
<thead>
<tr>
<th>P</th>
<th>Q</th>
<th>P and Q</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>1</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>0</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>
McCulloch Pitts Neuron for AND
McCulloch Pitts Model for logical AND

<table>
<thead>
<tr>
<th>X</th>
<th>Y</th>
<th>X+Y-2</th>
<th>Output</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>1</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>1</td>
<td>0</td>
<td>-1</td>
<td>-1</td>
</tr>
<tr>
<td>0</td>
<td>1</td>
<td>-1</td>
<td>-1</td>
</tr>
<tr>
<td>0</td>
<td>0</td>
<td>-2</td>
<td>-1</td>
</tr>
</tbody>
</table>
Also neurons for OR, NOT etc.

- More complex functions and formula can be represented as complex combinations of neurons
- Just in the same way we can build up logical formula
- Neurons give us a way to compute the functions with simple devices
Comparing Computers to Human Brains

- Computers much more “all or nothing” than human brains
- Error recovery rudimentary
- Capabilities either on or off

Idea behind neural computing: by modelling major features of the brain and its operation, we can produce computers that exhibit many of the useful properties of the brain.
So can machines think?

- Now or in the future?
- We could also ask whether people can think
  - How does that pink stuff inside our heads manage to produce what we take as intelligent behavior?
  - What in human anatomy gives rise to consciousness?
Behavioural Definitions

- In the absence of a clear understanding of intelligence and consciousness, what are the chances of arriving at a **behavioural** definition of thinking or intelligence?

- “Two things are identical if one can be substituted for the other without affecting the truth.” – Leibniz 1704

- “If it looks like a duck, walks like a duck and quacks like a duck, then it just may be a duck” – Reuther 1950s
The Turing Test

- Turing in 1950 published a philosophical paper designed to stop people arguing about whether or not machines could think.
- He proposed that the question be replaced with a test, which is what is now called the Turing Test.
Turing’s test

- A variation on a common parlor game called the imitation game
- An interrogator in another room asks questions of a subject by teletype to guess their gender.
- The subject is sometimes a man and sometimes a woman.
- Turing suggested a computer could replace a subject and one could ask whether the interrogator would notice.
- If, after some agreed time, the interrogator cannot distinguish situations where a machine has been substituted for the man/woman, we should just agree to say the machine can think.
Turing’s Prediction 1950

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 right identification after five minutes of questioning…… I believe that at the end of the century the use of words and general educated opinion will have altered so much that one will be able to speak of machines thinking without expecting to be contradicted.
Discussion question: Is that intelligence?

- Would you be satisfied that something which passed the TT was intelligent? What other requirements would you put on something before you considered it to be intelligent?
Is it obvious that Turing’s main prediction about 2000 was wrong?
Newell’s geography of AI 1969

- Predicate Calculus + Theorem Proving (1959)
- Robots (1968)
- Programming (1959)
- Pattern Recognition (1955)
- Concept Formation (1969)
- Induction (1964)
- Theorem Proving + Game Playing (1956)
- Optimisation (1965)
- Semantics 1969
- Design (1969)
- Knowledge + Belief Systems (1966)
- Natural Language Interpretation (1960)
- Conversation (1966)
AI IS HERE BUT IT IS NOTHING LIKE WHAT WE THOUGHT IT WOULD BE

The AI Revolution Is On

By Steven Levy December 27, 2010 12:00 pm Wired January 2011

Today’s A.I. bears little resemblance to its initial conception. The field’s trailblazers believed success lay in mimicking the logic-based reasoning that human brains were thought to use.

Photo: Dwight Eschliman; Illustration: Zee Rogér
Google Goggles

Use pictures to search the web. [Watch a video]

Get Google Goggles

Android (1.6+ required)
Download from Android Market.

Send Goggles to Android phone

New! iPhone (iOS 4.0 required)
Download from the App Store.

Send Goggles to iPhone

Google Goggles in action

Click the icons below to see the different kinds of objects and places you can search for using Google Goggles.

- Text
- Landmarks
- Books
- Contact Info
- Artwork
- Wine
- Logos
Hot Topics in AI now

- Core methods have moved away from logic and theorem proving
- Large focus on reasoning about uncertainty and probabilistic reasoning
- Machine learning
- Natural Language Processing: Almost all human knowledge is stored as language.
- Knowledge Discovery from the web
- Robotics
Robotics

- Robots make cars in all advanced countries
- Robot coaches and companions
- Unmanned vehicles, DARPA Grand Challenge.
- Military Applications
- Education, Nursing, Companionship

Interactive Systems

- Intelligent Virtual Agents
- Dialogue Systems
- Relational Agents
- Intelligent Tutoring and Training Systems
Variants of Information Presentation Systems with Virtual Characters

**tv-style**

**role plays**

**face-to-face dialogs**

**Multi-party Dialogue**
Affective Computing: Emotion Mirror
Agents that express emotions (E. Andre et al.)
Task Oriented Dialog Systems
Call Centres/Trouble Shooting Systems

- Call centers are a growing employment area, distributed around the world.
- Partial dialogue automation can save companies millions.
- Competition is IVR, or human?
- Can pass the Turing test?
- AT&T How May I Help You
- Speech Cycle: Internet connect
Alfred Experiment: Gaze & Personality

Bossy or Wimpy: Expressing Social Dominance by Combining Gaze and Linguistic Behaviors (Intelligent Virtual Agents 2010)

Collaboration with Elisabeth Andre’, U.Augsburg
Mary: Gesture & Personality

Evaluating the Effect of Gesture and Language on Personality Perception in Conversational Agents (Intelligent Virtual Agents 2010)
Collaboration with M. Neff, UC Davis
Alfred Experiment: Gaze & Personality

Extraversion + Dominance Reinforcing
High Extraversion + High Dom Gaze => Most Dominant
Low Extraversion + Low Dom Gaze => Least Dominant
Games & Reasoning

- IBM’s Deep Blue beat Kasparov at chess in 1997
- The world Go champion is a computer
- Expert systems like Turbotax get little publicity but link knowledge of tax law, editing forms, calculation etc. in a remarkable and satisfying way. (www.turbotax.com)
- Decision support systems like ActiveBuyer (www.activebuyersguide.com) help shoppers choose the right product
- Medical expert systems can outperform doctors in many areas of diagnosis
The web has changed everything?
Knowledge, Inference

- Search systems like Google are not perfect but very effective information retrieval
- Automatic knowledge discovery from web (e.g. labs.google.com/sets)
- Machine Translation
It doesn’t matter if the cat is white or black. If it can catch a mouse, it’s a good cat.

No importa si el gato es blanco o negro. Si se puede coger un ratón, que es un buen gato.
It doesn't matter if the cat is white or black. If it can catch a mouse, it's a good cat.

No importa si el gato es blanco o negro. Si se puede coger un ratón, que es un buen gato.

No matter if the cat is black or white. If you can catch a mouse, which is a good cat.
How does it do with colloquialisms?

We’d better get a move on if we’re going to be there by curtain time.

Será mejor que darse prisa si vamos a estar allí por tiempo de cortina.

You better hurry if we're going to be there for curtain time.
What about different meanings for the same word (word senses)?

**We went to the bank.**
*We took the fish to the bank.*

**Nos fuimos a la orilla.**
*Tomamos a los peces a la orilla.*

**We took the check to the bank.**
*We went fishing at the bank.*

**Tomamos el cheque al banco.**
*Fuimos a pescar en el banco*
What about different meanings for the same word (word senses?)

- We went to the bank.
- We took the check to the bank.
- We took the fish to the bank.
- We went fishing at the bank.
- We buried the fish on the bank.
- We buried the fish in the bank.

- Nos fuimos a la orilla.
- Tomamos el cheque al banco.
- Tomamos a los peces a la orilla.
- Fuimos a pescar en el banco.
- Enterramos a los peces en la orilla.
- Enterramos a los peces en el banco.
Will a computer ever translate perfectly?

- We know English is not context free, but it’s amazing on some level how well statistical translation works.
- Computer-aided translation currently in use, can save translators a lot of time.
- What kinds of techniques could improve it?
  - Grammatical representations
  - Deeper meaning representations?
  - Statistical semantic information: ‘words go in herds’
  - Meaning, relations, selectional type restrictions
Knowledge and “Common Sense” Reasoning

I want to get some inexpensive dog food.

- The food is not made out of dogs. (c.f., “I’m going to eat a lamb curry.”)
- The food is not for me to eat. (c.f., “I need to get a pizza.”)
- Dogs cannot buy their own food.
- I am going to buy this dog food. (c.f., “He needs to get a new attitude.”)
- I am not saying that I want to understand why some dog food is inexpensive. (e.g., “I need to get what he’s talking about.”)
- The dog food is probably not more than £1 per can.
What is required of a knowledge representation?

- **Representational adequacy:** It should allow you to represent all the knowledge you need to reason with.
- **Inferential adequacy:** It should allow new knowledge to be inferred from a basic set of facts.
- **Inferential efficiency:** Inferences should be made efficiently.
- **Clear Syntax and Semantics:** We should know what the allowable expressions of the language are and what they mean.
- **Naturalness:** The language should be reasonably natural and easy to use.
Building a knowledge base

- Knowledge engineering (Circa 1980’s)
  - Investigate domain
  - Create formal representation of objects
  - Interview domain experts
    - Knowledge Acquisition & Representation (TAKES YEARS)

- [http://wordnetweb.princeton.edu/perl/webwn](http://wordnetweb.princeton.edu/perl/webwn)

Now: Crowd Source It! Data Mine it! Both!

WordNet

- 70,000 synsets (synonym sets)
  - Simple, noun hierarchy

- Widely used in language processing:
  - Query expansion, IR, Translation
  - Online version
    - http://www.cogsci.princeton.edu/cgi-bin/webwn
WordNet 2.0 Search

Search word: greenhouse  Find senses

Overview for "greenhouse"

The noun "greenhouse" has 1 sense in WordNet.

1. greenhouse, nursery, glasshouse — (a building with glass walls and roof; for the cultivation and exhibition of plants under controlled conditions)

Search for Synonyms, ordered by estimated frequency of senses

✓ Show glosses
☐ Show contextual help

The adjective "greenhouse" has 1 sense in WordNet.

1. greenhouse -- (of or relating to or caused by the greenhouse effect; "greenhouse gases")

Search for Synonyms/Related Nouns of senses

✓ Show glosses
☐ Show contextual help
WordNet Resources

- “greenhouse” as noun (X)
  - Synonyms, “nursery”
  - Hypernyms (designating whole class, X IS_A), e.g., “building”
  - Hyponyms (designating subclass, Y IS_KIND_OF), e.g., “orangery”, “conservatory”
  - Meronyms (constituent parts or substance, X HAS_PART), e.g., “door”, “wall”
  - Polysemy count (number of senses of word in a syntactic category)
Verb *get* has 36 senses

1. *get, acquire* - come into the possession of something concrete or abstract; "She got a lot of paintings from her uncle"; "They acquired a new pet"; "Get your results the next day"; "Get permission to take a few days off from work"
   
   Derived form: *noun getting*
   
   Sample sentence:
   
   The children get the ball

2. *become, go, get* - enter or assume a certain state or condition; "He became annoyed when he heard the bad news"; "It must be getting more serious"; "her face went red with anger"; "She went into ecstasy"; "Get going!"
   
   --2 is one way to change state, turn
   
   Sample sentence:
   
   John will get angry

3. *get, let, have* - cause to move; cause to be in a certain position or condition; "He got his squad on the ball"; "This let me in for a big surprise"; "He got a girl into trouble"
   
   --3 is one way to make, get
   
   Sample sentences:
   
   Somebody ----s somebody PP
   Somebody ----s something PP
   Somebody ----s somebody to INFINITIVE

4. *receive, get, find, obtain, incur* - receive a specified treatment (abstract); "These aspects of civilization do not find expression or receive an interpretation"; "His movie received a good review"; "I got nothing but trouble for my good intentions"
   
   --4 is one way to change
   
   Sample sentence:
   
   Something ----s

5. *arrive, get, come* - reach a destination; arrive by movement or progress; "She arrived home at 7 o’clock"; "She didn’t get to Chicago until after midnight"

   Sample sentences:
Add to it! (Snow, Jurafsky et al)

**Example:** Using the "Y called X" Pattern for Hypernym Acquisition

MINIPAR path: `-N:desc;V,called,called,-V:vrel:N` → `<hypernym> ‘called’ <hyponym>`

None of the following links are contained in WordNet (or the training set).

<table>
<thead>
<tr>
<th>Hyponym</th>
<th>Hypernym</th>
<th>Sentence Fragment</th>
</tr>
</thead>
<tbody>
<tr>
<td>efflorescence</td>
<td>condition</td>
<td>...and a <strong>condition</strong> called efflorescence...</td>
</tr>
<tr>
<td>’neal_inc</td>
<td>company</td>
<td>...The <strong>company</strong>, now called O’Neal Inc...</td>
</tr>
<tr>
<td>hat_creek_outfit</td>
<td>ranch</td>
<td>...run a small <strong>ranch</strong> called the Hat Creek Outfit.</td>
</tr>
<tr>
<td>tardive_dyskinesia</td>
<td>problem</td>
<td>...irreversible <strong>problem</strong> called tardive dyskinesia...</td>
</tr>
<tr>
<td>hiv-1</td>
<td>aids_virus</td>
<td>...infected by the <strong>AIDS virus</strong>, called HIV-1...</td>
</tr>
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<td>bateau_mouche</td>
<td>attraction</td>
<td>...sightseeing <strong>attraction</strong> called the Bateau Mouche...</td>
</tr>
<tr>
<td>kibbutz_malkiyya</td>
<td>collective_farm</td>
<td>...Israeli <strong>collective farm</strong> called Kibbutz Malkiyya...</td>
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</table>
YAGO

Next week

- Focus on projects
  - Teams
  - Domain
  - Modules
- CS 240: First Lab, Wed 3:30 to 5:30?
- CS 140: First Lab, Thurs 2 to 4.