Artificial Intelligence
(AI)
CS-401

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Text Book

- **Text book:**
  - ✓ Artificial Intelligence: A Modern Approach by **Stuart Russell & Peter Norvig**
- **Recommended books:**
  - ✓ Artificial Intelligence and Intelligent Systems, N.P. PADHY
  - ✓ Practical Artificial Intelligence Programming with java, Mark Watson

Course Outline

Goal is to introduce you to set of Artificial Intelligence (AI) concepts & techniques. The course will cover broader AI concepts like:

- Agents & Environments
- Search Strategies
- Logic and Knowledge Representation
- Planning
- Reasoning under Uncertainty
- Machine Learning

First Week

- Introduction
  - What *is* AI? (and why is it so cool?)
  - Brief history of AI
  - What's the state of AI now?
  - Examples
  - Challenges (What AI can & can't do!)

What is AI??
Artificial **Intelligence**

What is Intelligence?

- Intelligence:
  - "**The capacity to learn and solve problems**" (Websters dictionary)
  - in particular,
    - *the ability to solve novel problems*
    - *the ability to think & act like humans*
    - *the ability to think & act rationally*
- Artificial Intelligence
  - build and understand intelligent entities or agents
  - Two main approaches: "**engineering**" versus "**cognitive modeling**"

What's involved in Intelligence?

1. Ability to interact with the real world
   - to perceive, understand, and act
   - e.g., speech recognition and understanding and synthesis
   - e.g., image understanding
   - e.g., ability to take actions, have an effect
2. Reasoning and Planning
   - modeling the external world, given input
   - solving new problems, planning, and making decisions
   - ability to deal with unexpected problems, uncertainties
3. Learning and Adaptation
   - we are continuously learning and adapting
   - our internal models are always being "updated"
     - e.g., a baby learning to categorize and recognize animals

Artificial Intelligence as Science

- **Physics**: Where did the ***physical universe come*** from and what laws guide its dynamics?
- **Biology**: How did ***biological life evolve and how*** do living organisms function?
- **Artificial Intelligence**: What is the nature of "***intelligence" and what*** constitutes intelligent behavior?

Artificial Intelligence as Engineering

- How can we **make software and machines** more **powerful**, **adaptive**, and easier to use?

  Examples:

  Speech recognition

  Natural language understanding

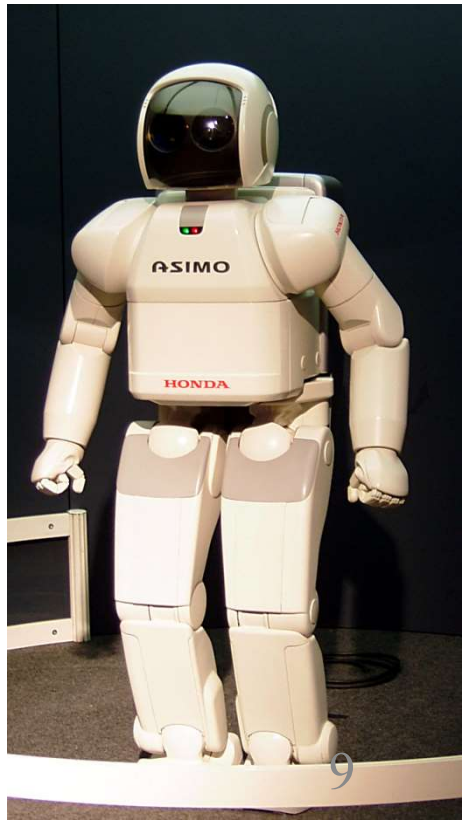
  Computer vision and image understanding

  Intelligent user interfaces

  Data mining

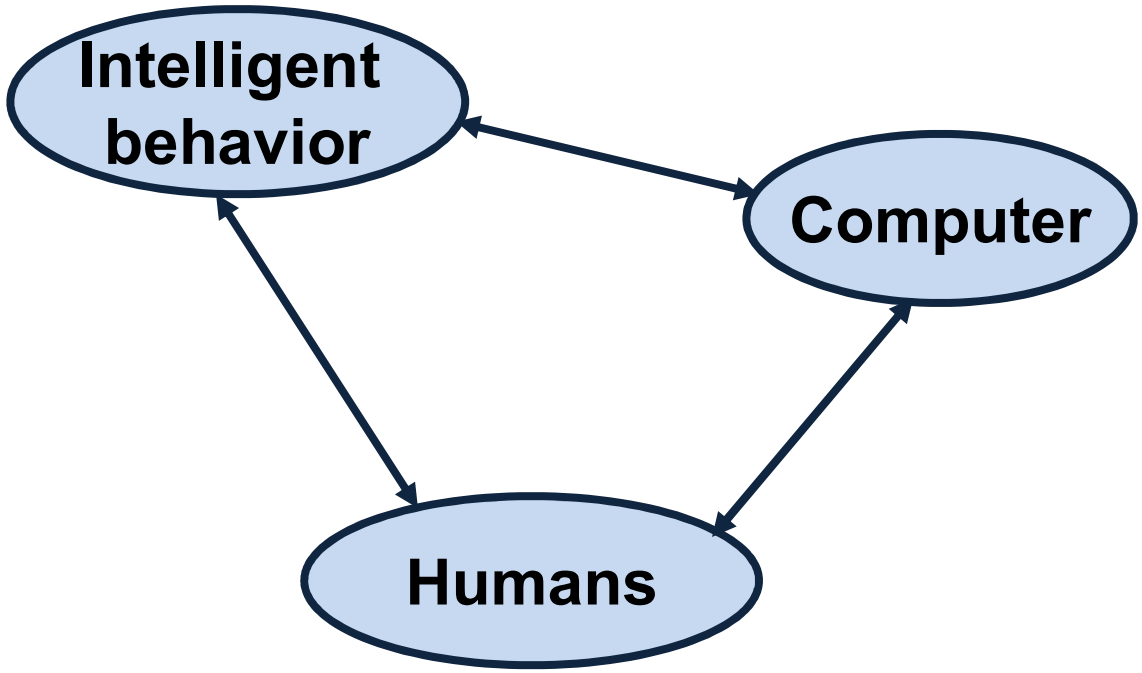
  Mobile robots, Softbots, Humanoids

  Medical expert systems…



What is AI? A simple Definition

- AI is the attempt for the reproduction of **human reasoning** and **intelligent behavior** by computational methods



Reasoning is the process of **thinking** about something in a **logical way** by establishing and verifying **facts** to draw **inferences** or **conclusions**.

Intelligent behavior is how a person performs " in **response to questions** and problems the **answers to which are NOT immediately known**" - Arthur L. Costa

What is AI?

Four possible ways to define Artificial Intelligence i.e.

A discipline that systematizes and automates reasoning processes to create machines that:

Act like humans	Act rationally
Think like humans	Think rationally

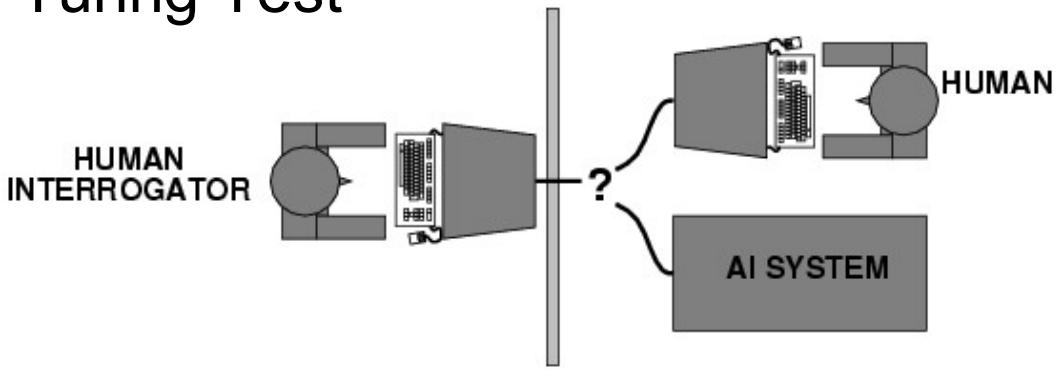
Act like humans	Act rationally
Think like humans	Think rationally

- The goal of AI is *to* ***create computer systems*** *that* ***perform tasks*** *regarded as requiring* ***intelligence*** *when done by* ***humans****.*
- In this AI Methodology we take a task at which people are better, e.g.:
  - **Prove a theorem**
  - **Play chess**
  - **Plan a surgical operation**
  - **Diagnose a disease**
  - **Navigate in a building**

  and build a computer system that does it automatically
- **But HUMANS MAKE ERRORS,,,,,do we want to duplicate or copy human imperfections?**

Machine Test: Act Like Humans

- The Turing Test



- What capabilities would a computer need to have to pass the Turing Test?
  - Natural language processing
  - Knowledge representation
  - Automated reasoning
  - Machine learning
- Turing predicted that by the year 2000, machines would be able to fool 30% of human judges for five minutes

A. Turing, Computing machinery and intelligence, Mind 59, pp. 433-460, 1950

Example Eliza – A partial success…

- ELIZA: A **program** that **simulated a psychotherapist** interacting with a patient and successfully passed the Turing Test.
- Coded at MIT during 1964-1966 by Joel Weizenbaum.
- **First script was DOCTOR**:
  - The script was a simple collection of **syntactic** patterns not unlike regular expressions
  - Each **pattern had** an **associated reply** which might include bits of the input (after simple transformations (my $\rightarrow$ your)
- Weizenbaum was shocked at reactions:
  - Psychiatrists thought it had potential.
  - People unequivocally related it to humans like response.
  - Many thought it solved the NL problem.

Another Application of the Turing Test

- **CAPTCHA**: **C**ompletely **A**utomatic **P**ublic **T**uring tests to tell **C**omputers and **H**umans **A**part
- E.g.:
  - Display visually distorted words
  - Ask user to recognize these words
- Example of application: Have only humans do the activity e.g., open email account.

AI is solved? Eugene Goostman

Computer AI passes Turing test in 'world first'

Eugene Goostman simulates a 13-year-old Ukrainian boy

9 June 2014 Last updated at 08:36 ET

A computer program called Eugene Goostman, which simulates a 13-year-old Ukrainian boy, is said to have passed the Turing test at an event organised by the University of Reading.

The test investigates whether people can detect if they are talking to machines or humans.

The experiment is based on Alan Turing's question-and-answer game **Can Machines Think?**

No computer has passed the test before under these conditions, it is reported.

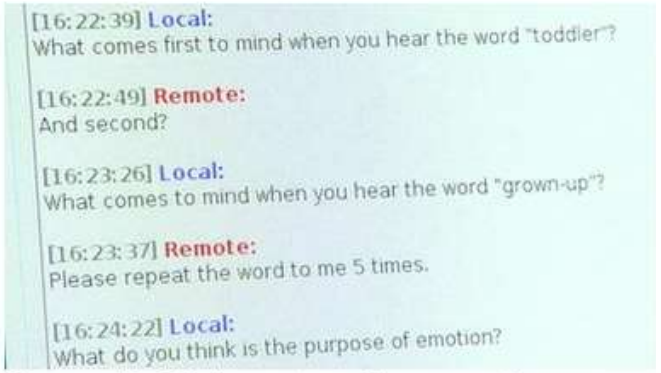
However, some artificial intelligence experts have disputed the victory, suggesting the contest had been weighted in the chatbot's favour.

The 65-year-old **Turing Test** is successfully passed if a computer is mistaken for a human more than 30% of the time during a series of five-minute keyboard conversations.

On 7 June Eugene convinced 33% of the judges at the Royal Society in London that it was human.

Other artificial intelligence (AI) systems also competed, including **Cleverbot**, **Elbot** and **Ultra Hal**.

Judges included actor Robert Llewellyn, who played an intelligent robot in BBC Two's science-fiction sitcom Red Dwarf, and Lord Sharkey, who led the successful campaign for Alan Turing's posthumous pardon, over a conviction for homosexual activity, in 2013.



Man or machine? A glimpse at one of the conversations.

Eugene was created by Vladimir Veselov, who was born in Russia and now lives in the United States, and Ukrainian-born Eugene Demchenko, who now lives in Russia.

Related Stories

- **How the Turing Test inspired AI**
- **Playing solitaire with Turing**
- **Is artificial intelligence possible?**

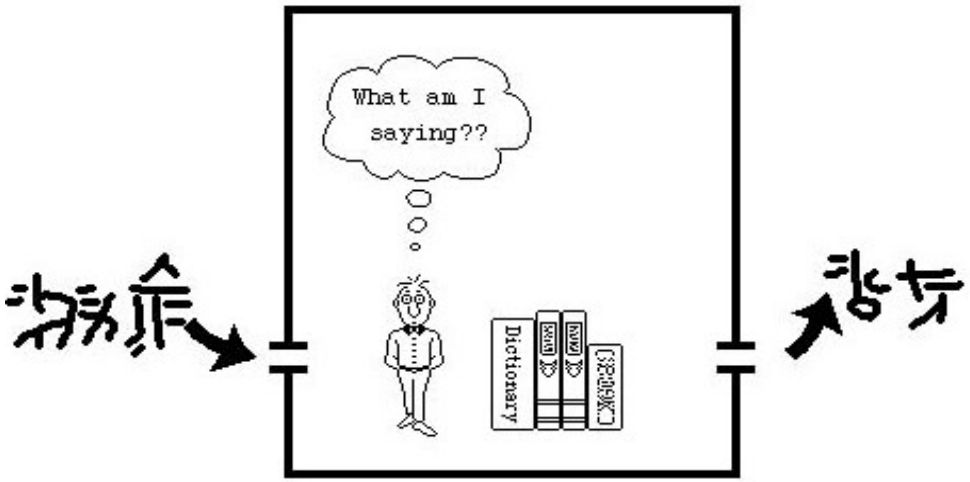
http://www.bbc.com/news/technology-27762088

http://en.wikipedia.org/wiki/Eugene_Goostman

http://www.scottaaronson.com/blog/?p=1858

What's wrong with the Turing test?

- Variability in protocols, judges
- Success depends on deception!
- Chatbots can do well using "cheap tricks"
  - First example: ELIZA (1966)
- Chinese room argument: one may simulate intelligence without having true intelligence (more of a philosophical objection)



A better Turing test?

THE NEW YORKER

AUGUST 16, 2013

WHY CAN'T MY COMPUTER UNDERSTAND ME?

POSTED BY GARY MARCUS

http://www.newyorker.com/online/blogs/elements/2013/08/why-cant-my-computer-understand-me.html

A better Turing test?

- **Multiple choice questions** that **can be easily answered by people** but **cannot be answered by computers** using "cheap tricks":

The trophy would not fit in the brown suitcase because it was so small.

What was so small?

- *The trophy*
- *The brown suitcase*

H. Levesque, *On our best behaviour*, IJCAI 2013
Published in International Joint Conference on Artificial Intelligence

A better Turing test?

- Multiple choice questions that **can be easily answered by people** but **cannot be answered by computers** using “cheap tricks”:

The trophy would not fit in the brown suitcase because it was so large.

What was so large?

- *The trophy*
- *The brown suitcase*

H. Levesque, *On our best behaviour*, IJCAI 2013

A better Turing test?

- Advantages over standard Turing test
  - Test can be administered and graded by machine
  - Does not depend on human subjectivity
  - Does not require ability to generate English sentences
  - Questions cannot be evaded using verbal dodges
  - Questions can be made “Google-proof” (at least for now…)

H. Levesque, *On our best behaviour*, IJCAI 2013

Act like humans	Act rationally
Think like humans	Think rationally

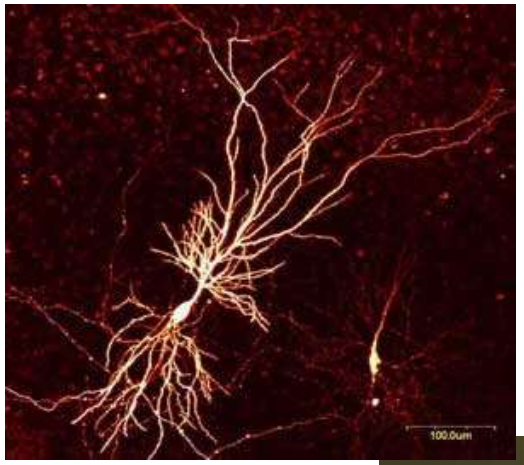
- In this type of approach to AI, how the computer performs tasks does matter and are inspired by human thinking.
- The **reasoning steps are important**…… done in the same fashion as humans process thoughts…
- **Ability to create and manipulate symbolic knowledge** (definitions, concepts, theorems, …)
- Example GPS (General Problem Solver): solved simple problems such as the **Towers of Hanoi** that could be sufficiently formalized. Problem: Explosion of states.
- **What is the impact of hardware on low-level reasoning, e.g., to go from signals to symbols?**

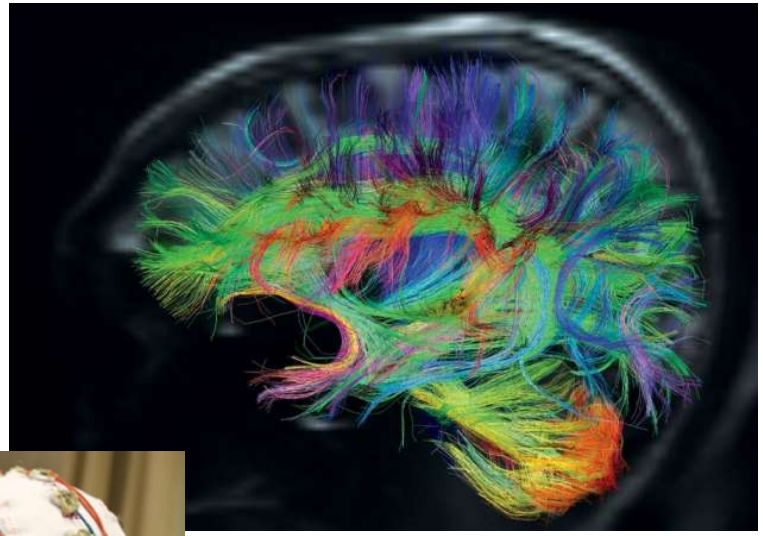
Act like humans	Act rationally
Think like humans	Think rationally

- Cognitive Science approach
  - Try to get "inside" our minds
  - e.g., conduct experiments with people to try to "reverse-engineer" how we reason, learn, remember, predict
- Problems
  - **Humans don't behave rationally**
    - e.g., insurance, politically motivated debate
  - The reverse engineering is very hard to do
  - The brain's hardware is very different to a computer program

AI definition 02: Think Like Humans

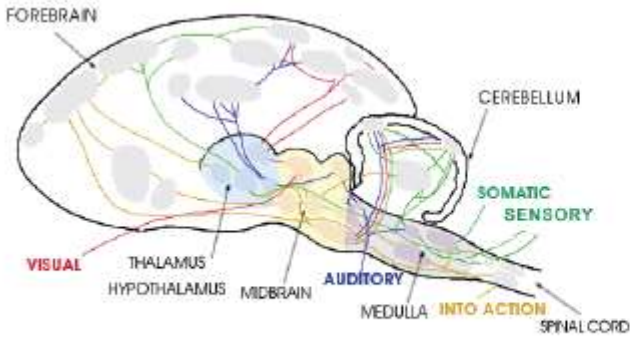
- Need to study the **brain as an information processing machine**: cognitive science and neuroscience





AI definition 02: Think Like Humans

- Can we build a brain?



10^{11} neurons
10^{14} synapses
cycle time: 10^{-3} sec

vs.

10^{9} transistors
10^{12} bits of RAM
cycle time: 10^{-9} sec

Source: L. Zettlemoyer

AI definition 02: Think Like Humans

the WHITE HOUSE

BRAIN INITIATIVE

BRAIN RESEARCH THROUGH ADVANCING INNOVATIVE NEUROTECHNOLOGIES

Since President Obama announced the **BRAIN Initiative** in April 2013, dozens of leading technology firms, academic institutions, scientists and other key contributors to the field of neuroscience have answered his call and made significant commitments to advancing the Initiative.

Human Brain Project

European Commission

FUTURE COMPUTING

Develop novel neuromorphic and neurorobotic technologies based on the brain's circuitry and computing principles.

Act like humans	**Act rationally**
Think like humans	**Think rationally**

- In this (**rational**) type of approach to AI, the goal is **to build agents that always make the "best" decision given what is available (knowledge, time, resources)**
- "Best" means maximizing the **expected value** of a utility function
- What is **the impact** of self-consciousness, emotions, desires, love for music, fear of dying, etc ... **on human intelligence? Are they part of Human Intelligence?**

AI definition 03: Thinking rationally

- **Idealized** or "**right**" way of thinking
- **Logic:** patterns of argument that always yield correct conclusions when supplied with correct premises
  - "Socrates is a man; all men are mortal; therefore Socrates is mortal."
- **Logicist approach to AI:** describe problem in formal logical notation and apply general deduction procedures/rules to solve it
- **Problems with the logicist approach**
  1. **Computational complexity** of finding the solution
  2. Describing real-world problems and knowledge in logical notation; becoz **not all facts are 100% true**.
  3. Dealing with **uncertainty/expected value**
  4. A lot of "rational" behavior has nothing to do with logic

AI definition 04: Acting rationally

- A *rational agent* **acts** to **optimally achieve** its **goals**
  - Goals are application-dependent and are expressed in terms of the **utility of outcomes**
  - Being rational means **maximizing your (expected) utility**
- This definition of rationality only concerns the **decisions/actions that are made**, not the **cognitive process** behind them
- In practice, a **rational agent** acts to **achieve best outcome** or when there is **uncertainty** the **best expected outcome**.

History

Ada Lovelace-1842

History of AI

- **1950: Turing**
  - Turing's "Computing Machinery and Intelligence“
- **1956: Birth of AI**
  - Dartmouth meeting: "Artificial Intelligence“ name adopted
- **1950s: initial promise**
  - **Early AI programs, including**:
    - Samuel's checkers program
    - Newell & Simon's **Logic Theorist**
- **1955-65: “great enthusiasm”**
  - Newell and Simon: GPS, general problem solver
  - Gelertner: Geometry Theorem Prover
  - McCarthy: invention of LISP

History of AI

- **1966—73: Reality dawns / WINTER OF AI**
  - Realization that many AI problems are intractable (difficult to handle or manage e.g. Speech Recognition, NLP etc.)
- **1969—85: Adding domain knowledge**
  - Development of knowledge-based systems
  - Success of rule-based expert systems,
    - E.g., DENDRAL (mol. Structure predictor), MYCIN (blood infections)
    - But were brittle (less adaptable) and did not scale well in practice
- **1986-- Rise of machine learning**
  - Neural networks return to popularity
  - Major advances in machine learning algorithms and applications
- **1990-- Role of uncertainty**
  - Bayesian networks as a knowledge representation framework
- **1995-- AI is opted as a Science**
  - Integration of learning, reasoning, knowledge representation, vision, NLP etc.

After All this Debate the question remains….

Can Machines Act/Think Intelligently?

- Yes, if intelligence is narrowly defined as information processing

  AI has made impressive achievements showing that tasks initially assumed to require intelligence can be automated

- Maybe yes and maybe not, if intelligence is not separated from the rest of "being human"

Success Stories AI Systems

Self-driving cars

Traffic Ahead

Many carmakers are developing prototype vehicles that are capable of driving autonomously in certain situations. The technology is likely to hit the road around 2020.

	BMW	Mercedes-Benz	Nissan	Google	General Motors
VEHICLE	5 Series (modified)	S 500 Intelligent Drive Research Vehicle	Leaf EV (modified)	Prius and Lexus (modified)	Cadillac SRX (modified)
KEY TECHNOLOGIES	• Video camera tracks lane markings and reads road signs • Radar sensors detect objects ahead • Side laser scanners • Ultrasonic sensors • Differential GPS • Very accurate map	• Stereo camera sees objects ahead in 3-D • Additional cameras read road signs and detect traffic lights • Short- and long-range radar • Infrared camera • Ultrasonic sensors	• Front and side radar • Camera • Front, rear, and side laser scanners • Four wide-angle cameras show the driver the car's surroundings	• LIDAR on the roof detects objects around the car in 3-D • Camera helps detect objects • Front and side radar • Inertial measuring unit tracks position • Wheel encoder tracks movement • Very accurate map	• Several laser sensors • Radar • Differential GPS • Cameras • Very accurate map

MIT Technology Review

http://www.technologyreview.com/featuredstory/520431/driverless-cars-are-further-away-than-you-think/

Google plans to assemble a test fleet of 100 electric two-seat prototypes in 2015

Uber employee of the future: The self-driving car

Speech and natural language

Welcome to Skype Translator Preview

Breaking the language barrier – one conversation at a time.

Skype Translator gives you the ability to speak another language without learning one. Simply set up a Skype video or voice call with someone who speaks another language and start talking. Translator is currently available in English and Spanish. More languages are coming soon.

When you use Translator:

✓ Your conversation is translated into another language in near real-time.

✓ What someone else says is translated back in your language.

✓ An on-screen transcript of your call is displayed.

✓ And you can send instant messages across 40+ languages.

http://www.skype.com/en/translator-preview/

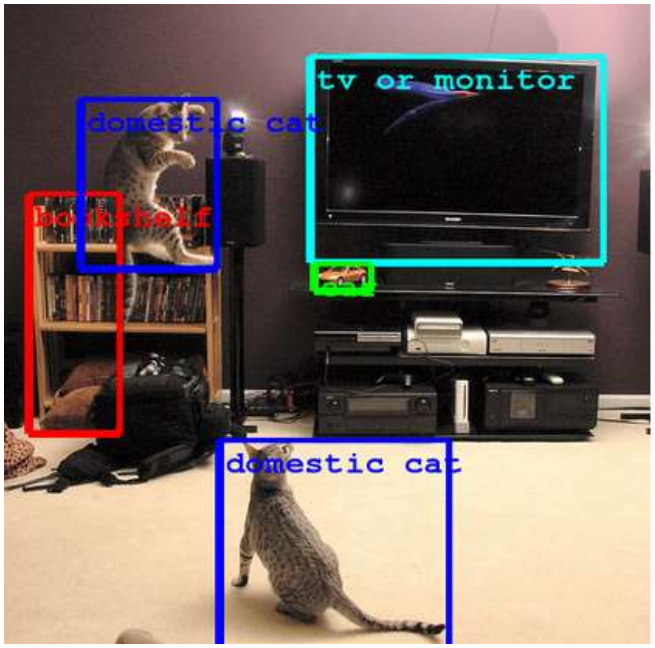
Hallo, hola, olá to the new, more powerful Google Translate app

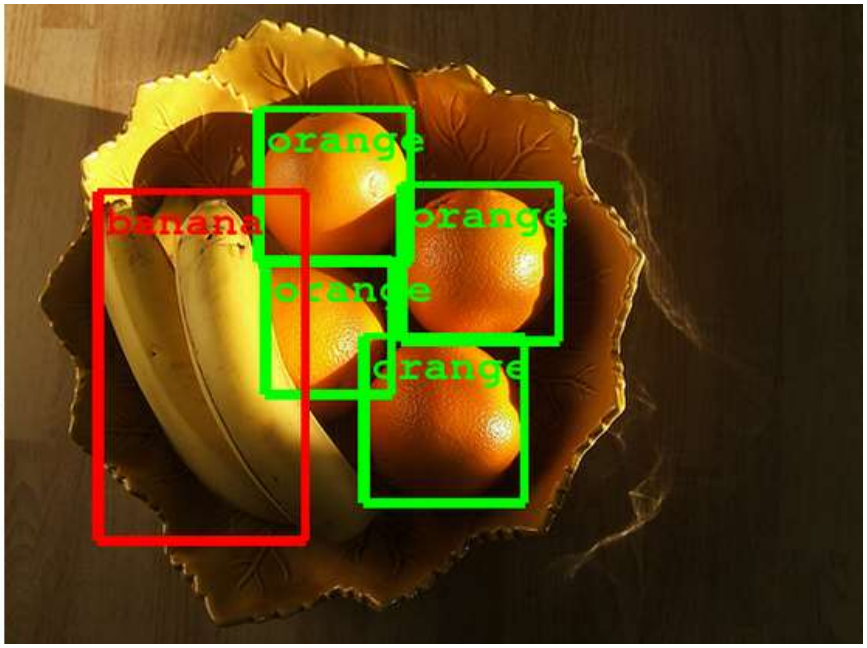
Posted: Wednesday, January 14, 2015

- **Instant translation with Word Lens**
- **Have a conversation with Google Translate**

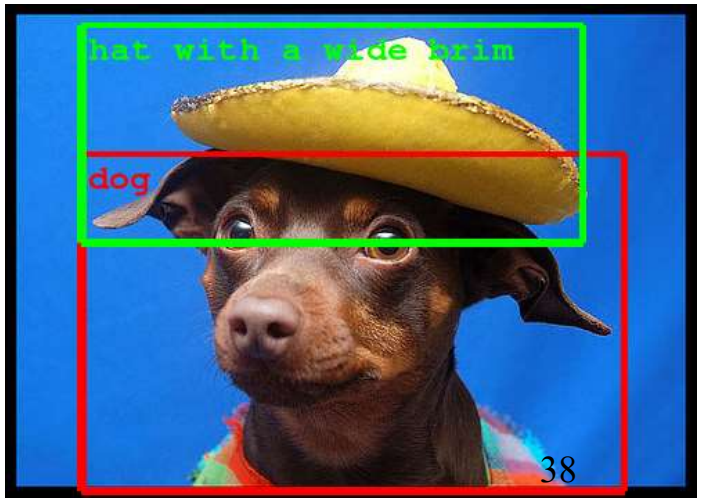
http://googleblog.blogspot.com/2015/01/hallo-hola-ola-more-powerful-translate.html

Vision





- [Computer Eyesight Gets a Lot More Accurate](), NY Times Bits blog, August 18, 2014
- [Building A Deeper Understanding of Images](), Google Research Blog, September 5, 2014
- [Baidu caught gaming recent supercomputer performance test](), Engadget, June 3, 2015



Games

- 1997: IBM's Deep Blue defeats the reigning world chess champion Garry Kasparov
  - **1996: Kasparov Beats Deep Blue**
    "I could feel – I could smell – a new kind of intelligence across the table."
  - **1997: Deep Blue Beats Kasparov**
    "Deep Blue hasn't proven anything."

- 2007: Checkers is solved
  - Though checkers programs had been beating the best human players for at least a decade before then
- 2014: Heads-up limit Texas Hold-em poker is solved
  - First game of imperfect information
- 2015: Deep reinforcement learning beats humans at classic arcade games

Mathematics

- In 1996, a computer program written by researchers at Argonne National Laboratory proved a mathematical conjecture unsolved for decades
  - NY Times story: "*[The proof] would have been called creative if a human had thought of it*"
- Mathematical software:

$$
\begin{aligned}
\partial_r^2 u &= -\left[E' - \frac{l(l+1)}{r^2} - r^2\right] u(r) \\
e^{-2s}\left(\partial_s^2 - \partial_s\right) u(s) &= -\left[E' - l(l+1)e^{-2s} - e^{2s}\right] u(s) \\
e^{-2s}\left[e^{\frac{1}{2}s}\left(e^{-\frac{1}{2}s}u(s)\right)'' - \frac{1}{4}u\right] &= -\left[E' - l(l+1)e^{-2s} - e^{2s}\right] u(s) \\
e^{-2s}\left[e^{\frac{1}{2}s}\left(e^{-\frac{1}{2}s}u(s)\right)''\right] &= -\left[E' - \left(l+\frac{1}{2}\right)^2 e^{-2s} - e^{2s}\right] u(s) \\
v'' &= -e^{2s}\left[E' - \left(l+\frac{1}{2}\right)^2 e^{-2s} - e^{2s}\right] v
\end{aligned}
$$

Logistics, scheduling, planning

- During the 1991 Gulf War, US forces deployed an AI logistics planning and scheduling program that involved up to 50,000 vehicles, cargo, and people
- NASA's Remote Agent software operated the Deep Space 1 spacecraft during two experiments in May 1999
- In 2004, NASA introduced the MAPGEN system to plan the daily operations for the Mars Exploration Rovers

Robotics

- Mars rovers
- Autonomous vehicles
  - DARPA Grand Challenge
  - Self-driving cars
- Autonomous helicopters
- Robot soccer
  - RoboCup
- Personal robotics
  - Humanoid robots
  - Robotic pets
  - Personal assistants?

DARPA Robotics Challenge (2015)

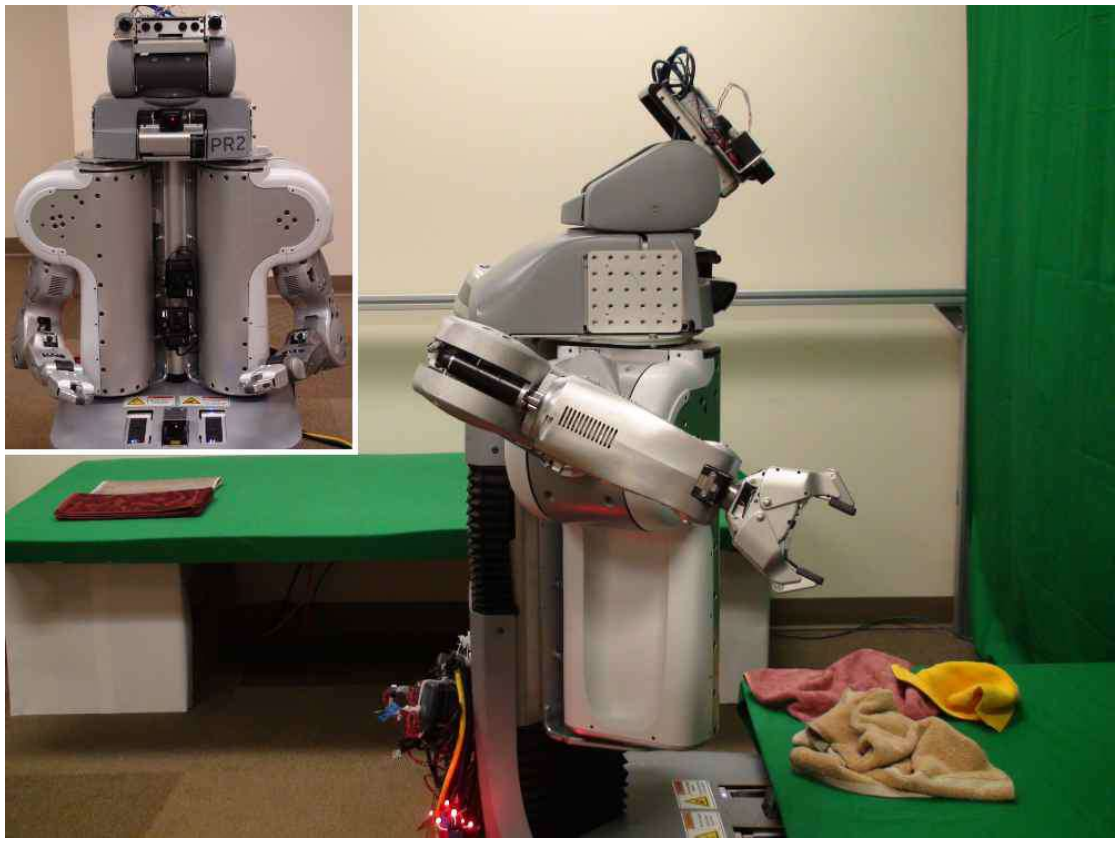
JUN 5, 2015 @ 3:24 PM

NEW TECHNOLOGY ROBOTS DARPA ROBOTS DARPA ROBOTICS CHALLENGE

The Most Hilarious Robo-Falls from the DARPA Robotics Challenge

http://www.popularmechanics.com/technology/robots/a15907/best-falls-from-darpa-robot-challenge/

Towel-folding robot



YouTube Video

- J. Maitin-Shepard, M. Cusumano-Towner, J. Lei and P. Abbeel, Cloth Grasp Point Detection based on Multiple-View Geometric Cues with Application to Robotic Towel Folding, ICRA 2010
- More clothes folding

What AI systems can't do yet?

- Understand natural language robustly (e.g., read and **understand** articles in a newspaper)
- Surf the web
- Interpret an arbitrary visual scene
- Learn a natural language
- Play Go well
- Construct plans in dynamic real-time domains
- Refocus attention in complex environments
- Perform life-long learning

Can't Exhibit true autonomy and intelligence yet! ☹

The End