

# COMP3411/9814: Artificial Intelligence

## Foundations

# Course Materials

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- ❑ WebCMS3
- ❑ Open Learning
- ❑ <http://www.cse.unsw.edu.au/~cs3411>
- ❑ <https://webcms3.cse.unsw.edu.au/COMP3411/20T0>

## Lecturer-in-Charge

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- ❑ Tatjana Zrimec
- ❑ [t.zrimec@unsw.edu.au](mailto:t.zrimec@unsw.edu.au)
- ❑ J17-510

# Lecture Schedule

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Course	Time	Location
COMP3411-9814	Mon 12:00 - 14:00	RC Theatre
COMP3411-9814	Wed 12:00 - 14:00	RC Theatre
COMP3411-9814	Thu 12:00 - 14:00	RC Theatre

# Tutorials and Labs

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## Tutorials

Course	Time	Room	Room
COMP3411	Wed 10:00 - 11:00	W10A - RedC 2035	W10B - RedC M010
COMP3411	Thu 11:00 - 12:00	W11A - RedC 2035	W11B - RedC M010
COMP9814	Wed 10:00 - 11:00	W10A - RedC 2035	W10B - RedC M010
COMP9814	Thu 11:00 - 12:00	W11A - RedC 2035	W11B - RedC M010

## Labs

Course	Time	Room	Room
COMP3411	Wed 15:00 - 17:00	W15A -BongoK17G7	W15B -TablaK17G7
COMP3411	Thu 15:00 - 17:00	H15A - BongoK17G7	H15B - TablaK17G7
COMP9814	Wed 15:00 -17:00	W15A -BongoK17G7	W15B -TablaK17G7
COMP9814	Thu 11:00 - 12:00	H15A - BongoK17G7	H15B - TablaK17G7

Labs are not compulsory

# Planned Topics

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## **AI, Agents & Prolog**

- What is AI?
- Agents, Agent Types
- Tasks
- Prolog Programming

## **Solving Problems by Search**

- Path Search
- Heuristic Path Search
- Constraint Satisfaction

## **Machine Learning**

- Supervised Machine Learning
- Neural Networks
- Reinforcement Learning

## **Knowledge and Reasoning**

- Uncertainty
- Logic
- Knowledge Representation
- Knowledge Based Systems

# What To Do (This Week)

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- ❑ Sign up to OpenLearning (through Moodle)
- ❑ Work through this week's Learning Activities
- ❑ Set up and log into your CSE account
- ❑ Start working through the Prolog Exercises

# Why Prolog?

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- ❑ Very useful for AI and search
- ❑ Good for you to see an example of a non-imperative language
- ❑ Logic programming languages like Prolog have recently had a resurgence of popularity in the computing industry

# Resources

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## Recommended Text:

- ❑ David L. Poole and Alan K. Mackworth *Artificial Intelligence: Foundations of Computational Agents*, 2nd Edition

## Additional reference material

- ❑ Stuart Russell and Peter Norvig, *Artificial Intelligence: a Modern Approach*, 3rd Edition, Prentice Hall, 2009.
- ❑ Ivan Bratko, *Programming in Prolog for Artificial Intelligence*, 4th Edition, Pearson, 2013.



# Electronic Resources

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## Textbook:

- Artificial Intelligence: Foundations of Computational Agents, 2nd Edition  
David L. Poole and Alan K. Mackworth

## Prolog:

- [SWI-Prolog](#)
- [SWI-Prolog reference manual](#)

NLTK: Natural Language Toolkit

Scikit Learn: Machine Learning in Python

Python Tutorial: The Python Tutorial

Anaconda: Solutions for Data Science Practitioners and Enterprise Machine Learning

# Assessment

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Assessment will consist of:

Assignments 40%

Written Exam 60%

In order to pass the course, you must score

- at least 16/40 for the assignments
- at least 24/60 for the exam
- a combined mark of at least 50/100

# Assignments

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The assignments may, for example, involve writing a program to:

- ❑ enable an agent to act in a simulated environment
- ❑ solve a problem using search techniques
- ❑ play a game
- ❑ apply a machine learning algorithm

# Plagiarism

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- ❑ ALL work submitted for assessment must be your own work
- ❑ for an individual assignment, collaborative work in the form of “think tanking” is encouraged, but students are not allowed to derive code together as a group during such discussions
- ❑ in the case of a group assignment, code must not be obtained from outside the group
- ❑ plagiarism detection software may be used on submitted work
- ❑ UNSW Plagiarism Policy:  
<https://student.unsw.edu.au/plagiarism>

# Related Courses

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- ❑ COMP9417 Machine Learning and Data Mining
- ❑ COMP4418 Knowledge Representation and Reasoning
- ❑ COMP3431 Robotic Software Architecture
- ❑ COMP9517 Machine Vision
- ❑ COMP9444 Neural Networks and Deep Learning
- ❑ 4th Year Thesis topics

# Lecture Overview

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- ❑ What is Artificial Intelligence?
- ❑ Foundations of AI

# What is Artificial Intelligence?

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<b>Thinking Humanly</b>	<b>Thinking Rationally</b>
<b>Acting Humanly</b>	<b>Acting Rationally</b>

# What is Artificial Intelligence?

**Thinking Humanly**

“The exciting new effort to make computers think . . . machines with minds, in the full and literal sense.” (Haugeland, 1985) “[The automation of] activities that we associate with human thinking, activities such as decision-making, problem solving, learning . . .” (Bellman, 1978)

**Thinking Rationally**

“The study of mental faculties through the use of computational models.” (Charniak and McDermott, 1985)  
“The study of the computations that make it possible to perceive, reason, and act.” (Winston, 1992)

**Acting Humanly**

“The art of creating machines that perform functions that require intelligence when performed by people.” (Kurzweil, 1990)  
“The study of how to make computers do things at which, at the moment, people are better.” (Rich and Knight, 1991)

**Acting Rationally**

“Computational Intelligence is the study of the design of intelligent agents.” (Poole et al., 1998)  
“AI . . . is concerned with intelligent behavior in artifacts.” (Nilsson, 1998)



# What is Artificial Intelligence?

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- ❑ Artificial Intelligence is the synthesis and analysis of computational agents that act intelligently.
- ❑ An agent is something that acts in an environment.
- ❑ An agent acts intelligently if:
  - its actions are appropriate for its goals and circumstances
  - it is flexible to changing environments and goals
  - it learns from experience
  - it makes appropriate choices given perceptual and computational limitations

# Examples of Agents

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- ❑ **Organisations** Microsoft, Al Qaeda, Government of Canada, UBC, CS Dept,...
- ❑ **People** teacher, physician, stock trader, engineer, researcher, travel agent, farmer, waiter...
- ❑ **Computers/devices** thermostat, user interface, airplane controller, network controller, game, advising system, tutoring system, diagnostic assistant, robot, Google car, Mars rover...
- ❑ **Animals** dog, mouse, bird, insect, worm, bacterium, bacteria...
- ❑ book(?), sentence(?), word(?), letter(?)

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Can a book or article do things?

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Can a book or article do things?

Convince? Argue? Inspire? Cause people to act differently?

# Goals of Artificial Intelligence

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- ❑ **Scientific goal:** to understand the principles that make intelligent behaviour possible in natural or artificial systems.
  - analyse natural and artificial agents
  - formulate and test hypotheses about what it takes to construct intelligent agents
  - design, build, and experiment with computational systems that perform tasks that require intelligence
- ❑ **Engineering goal:** design useful, intelligent artefacts.

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- ❑ **Engineering goal:** design useful, intelligent artefacts.
- ❑ Analogy between studying flying machines and thinking machines.

# Foundations of AI

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- ❑ Philosophy (428 B.C — present)
- ❑ Mathematics (c. 800 — present)
- ❑ Psychology (1879 — present)
- ❑ Linguistics (1957 — present)
- ❑ Computer engineering (1940 — present)
- ❑ Biocybernetics (1940's — present)
- ❑ Neurology (1950's — present)

# Foundations of AI - Philosophy

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## ❑ Philosophy / Arts

- what is mind ? -- > mind is like a machine
- it operates on knowledge encoded in an “internal language”
- thought and reasoning can be used to arrive at the right actions
- what is consciousness ?



# Foundations of AI - Mathematics

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- ❑ Philosophy
- ❑ Mathematics / Physics / Statistics / Logic
  - tools to manipulate logical statements
  - tools to manipulate probabilistic statements
  - algorithms and their analysis
  - complexity issues
  - dynamical systems / RNNs
  - statistical physics / Hopfield nets
  - methods for pattern recognition
  - models using differential equations, statistics, etc.

# Foundations of AI - Psychology

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- ❑ Philosophy
- ❑ Mathematics
- ❑ Psychology / Cognitive Science
  - humans and animals are information processing machines
  - introspection
  - experiments
  - what is intelligence ?  
(<http://www.iqtest.com/>)
  - what is learning and memory ?

# Foundations of AI - Linguistics

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- ❑ Philosophy
- ❑ Mathematics
- ❑ Psychology
- ❑ Linguistics / Computational Linguistics / Formal Languages
  - language use fits into the ‘information processing machine’ model
  - Chomsky hierarchy
  - natural language processing

# Foundations of AI - Engineering

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- ❑ Philosophy
- ❑ Mathematics
- ❑ Psychology
- ❑ Linguistics
- ❑ Computer Engineering
  - build computers and robots fast enough to make AI applications
  - links to mechanical engineering

# Foundations of AI - Neurobiology

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- ❑ Philosophy
- ❑ Mathematics
- ❑ Psychology
- ❑ Linguistics
- ❑ Computer Engineering
- ❑ Biocybernetics and Neurobiology
  - molecular level
  - single cell recordings
  - cell circuit level
  - information processing in biological systems

# Foundations of AI - Neurology

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- ❑ Philosophy
- ❑ Mathematics
- ❑ Psychology
- ❑ Linguistics
- ❑ Computer Engineering
- ❑ Biocybernetics and Neurobiology
- ❑ Neurology / Psychiatry
  - drugs
  - learning from disorders
  - brain scans (EEG/MEG/PET/MRI)

# Foundations of AI

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- ❑ Philosophy
- ❑ Mathematics
- ❑ Psychology
- ❑ Linguistics
- ❑ Computer Engineering
- ❑ Biocybernetics and Neurobiology
- ❑ Neurology / Psychiatry

AI is a central topic of current interdisciplinary scientific investigation.

# Theories about Intelligence

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- ❑ 380BC Plato (Rationalism - innateness)
- ❑ 330BC Aristotle (Empiricism - experience)
- ❑ 1641 Descartes (mind-body Dualism)
- ❑ 1781 Kant (Critique of Pure Reason)
- ❑ 1899 Sigmund Freud (Psychology)
- ❑ 1953 B.F. Skinner (Behaviourism)



# Artificial Intelligence in Literature

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- ❑ Greek Mythology (Pygmalion, Talos)
- ❑ 1580 Rabbi Loew (Golem, a clay man brought to life)
- ❑ 1818 Mary Shelley (Frankenstein)
- ❑ 1883 Carlo Collodi (Pinocchio)
- ❑ 1920 Karel Capek (Rossum's Universal Robots)
- ❑ 1950 Isaac Asimov (Three Laws of Robotics)
- ❑ 1951 Osamu Tezuka (Astro Boy)

# Robots - Good or Evil?

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# Artificial Intelligence Origins

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- ❑ 1642 Blaise Pascal (mechanical adding machine)
- ❑ 1694 Gottfried Leibniz (mechanical calculator)
- ❑ 1769 Wolfgang von Kempelen (Mechanical Turk)
- ❑ 1837 Charles Babbage & Ada Lovelace (Difference Engine)
- ❑ 1848 George Boole (the Calculus of Logic)
- ❑ 1879 Gottlob Frege (Predicate Logic)
- ❑ 1950 Turing Test
- ❑ 1956 Dartmouth conference

# What is Intelligence?

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# Turing Test

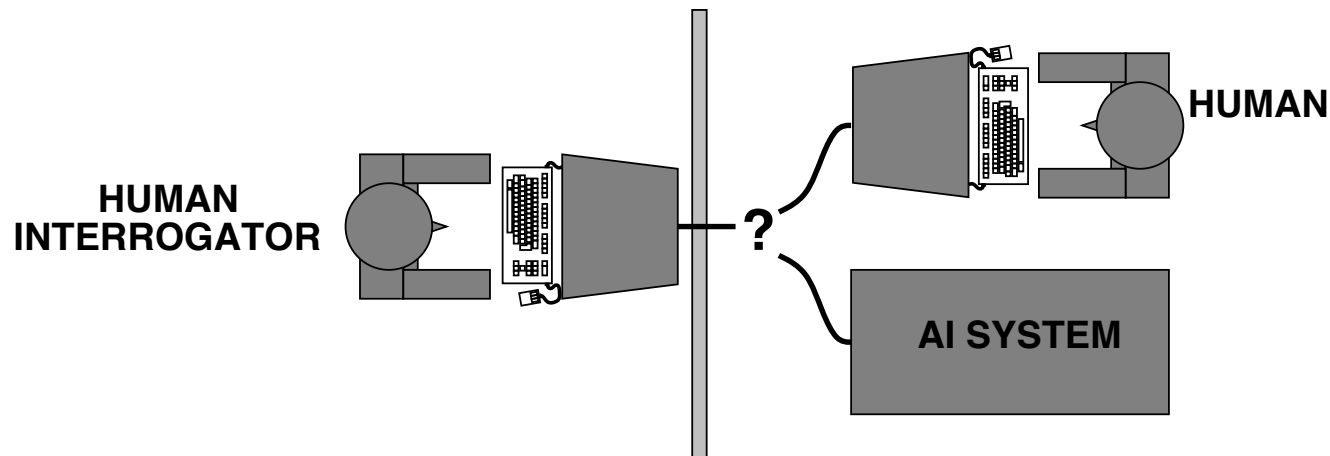
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- ❑ proposed by Alan Turing in 1950
- ❑ a human interrogates/converses with the computer via a teletype
- ❑ The aim is for the computer to **imitate** a human well enough to fool the human interrogator



# Turing Test

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- ❑ Turing thought a computer would pass this test by end of the 20th century.
- ❑ The Loebner Prize (Turing test) competition is held each year.
- ❑ The “Total Turing Test” allows physical objects to be passed to the machines as well as characters via the teletype.

# Extract from Turing paper

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- ❑ **Interrogator:** In the first line of your sonnet which reads ‘Shall I compare thee to a summer’s day’, would not ‘a spring day’ do as well or better?
- ❑ **Witness:** It wouldn’t scan.
- ❑ **Interrogator:** How about ‘A winter’s day’ – That would scan all right.
- ❑ **Witness:** Yes, but nobody wants to be compared to a winter’s day.
- ❑ **Interrogator:** Would you say Mr. Pickwick reminded you of Christmas?
- ❑ **Witness:** In a way.
- ❑ **Interrogator:** Yet Christmas is a winter’s day, and I do not think Mr. Pickwick would mind the comparison.
- ❑ **Witness:** I don’t think you’re serious. By a winter’s day one means a typical winter’s day, rather than a special one like Christmas.

# Eliza Session

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**Doctor:** What brought you here to see me today?

**Visitor:** Oh, nothing much. I'm feeling a bit tired, that's all.

**Doctor:** Why do you think you're feeling a bit tired?

**Visitor:** Well, I've been traveling a lot, and away from home.

**Doctor:** Tell me more about your family.



# Eliza Session

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**Visitor:** The trouble is, my mother's ill.

**Doctor:** How long has she been ill?

...

**Visitor:** The trouble is, my mother's Irish.

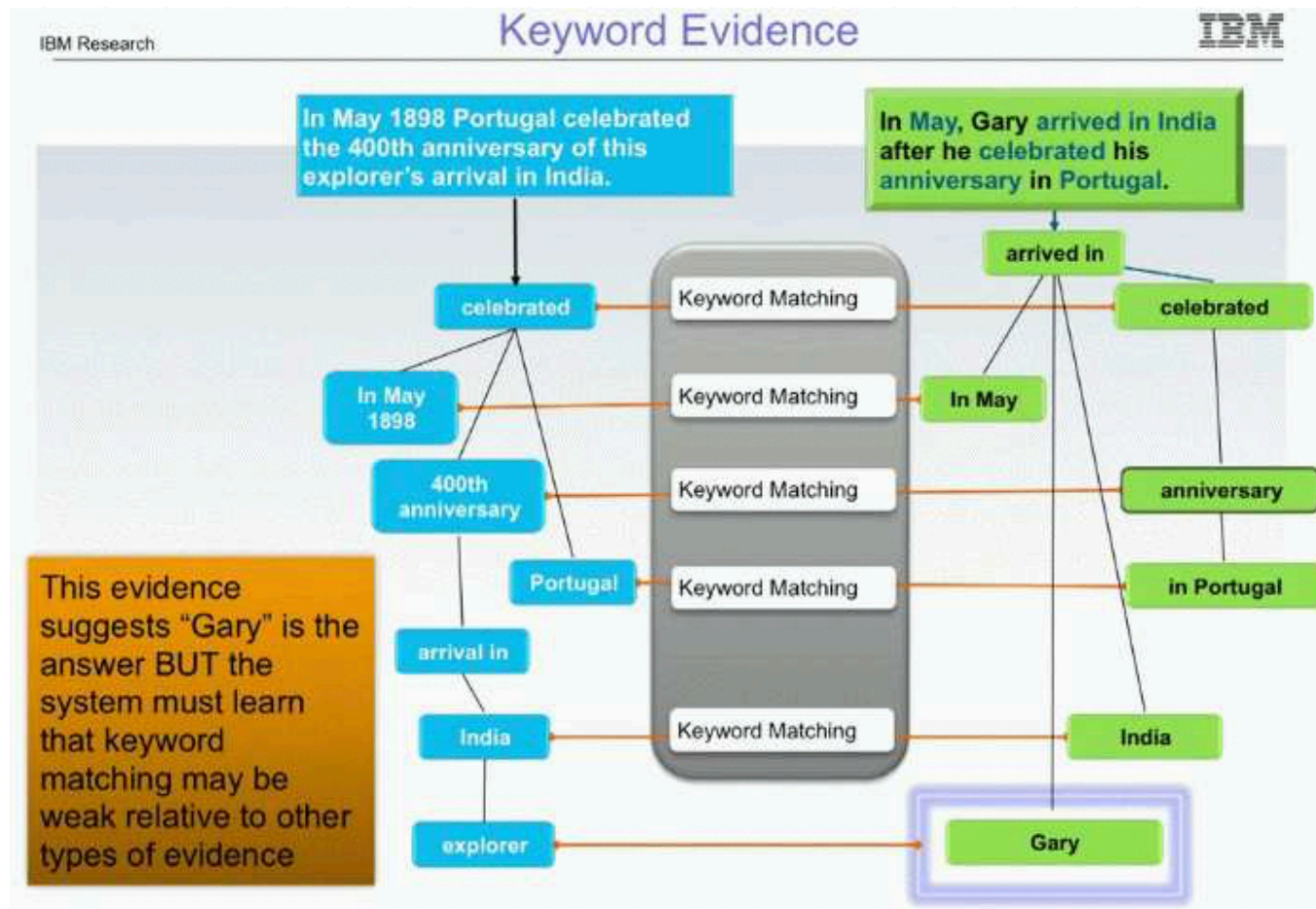
**Doctor:** How long has she been Irish?

...

**Visitor:** The trouble is, my mother's poodle.

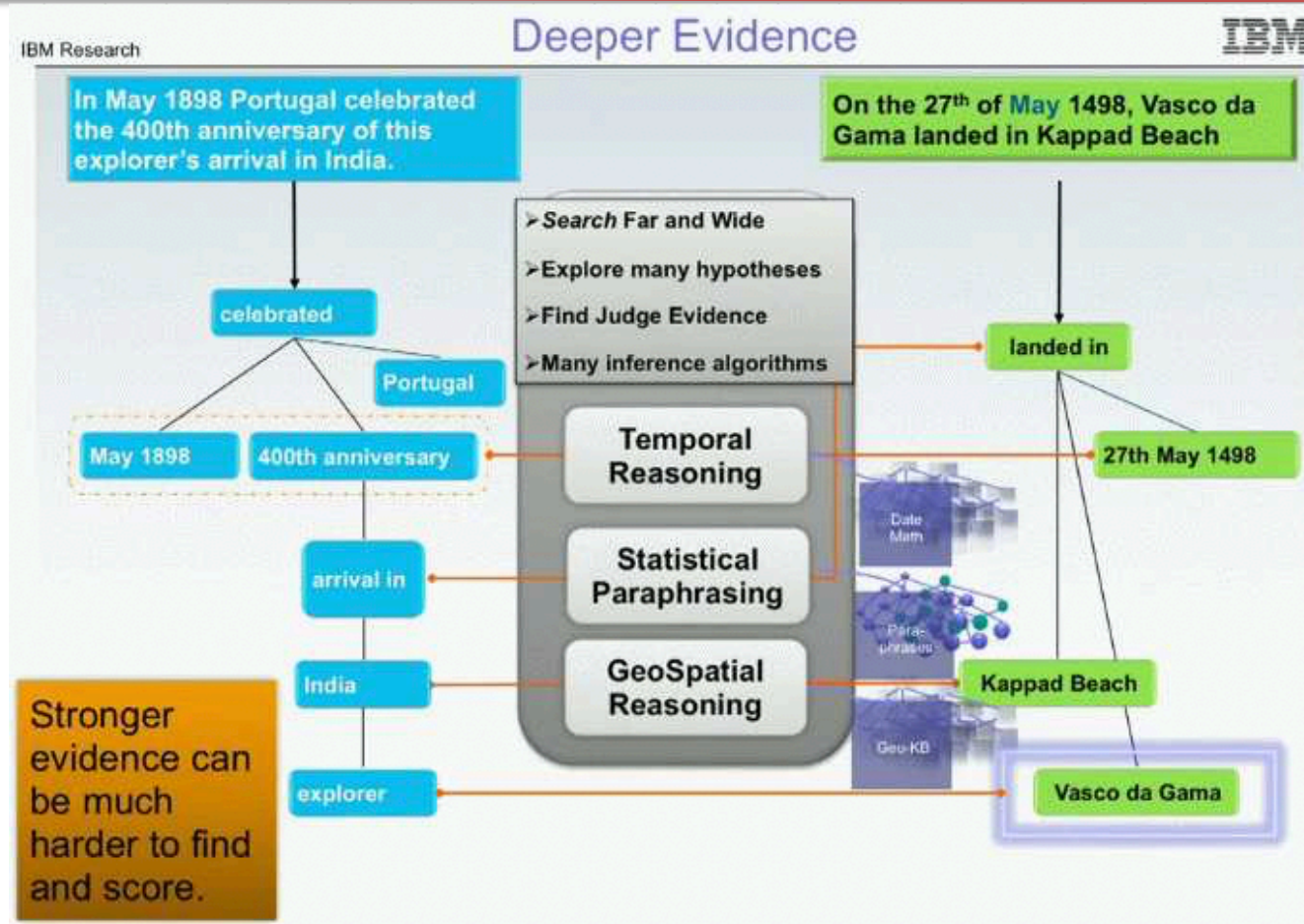
**Doctor:** How long has she been poodle?

# IBM Watson DeepQA



YouTube: "Building Watson - A Brief Overview of the DeepQA Project"

# IBM Watson DeepQA



YouTube: “Building Watson - A Brief Overview of the DeepQA Project”

# Critiques of Turing Test (or AI in general)

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- ❑ Misplaced emphasis on abstract reasoning rather than low-level perception and behaviour
  - Intelligence Without Reason (Brooks 1991)
- ❑ General Intelligence vs. Specific Modules
  - “How the Mind Works” (Pinker, 1997)
- ❑ Philosophical Objections to AI
  - Gödel’s Theorem, Undecidability (Lucas 1961, Penrose 1989)
  - Chinese Room (Searle 1980)
  - “What Computers (Still) Can’t Do” (Dreyfus 1972,1993)

# Chess, Vision - Easy or Hard?

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# State of the art

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Which of the following can be done at present?

- ☐ Play a decent game of table tennis (ping-pong)
- ☐ Drive in the center of Cairo, Egypt
- ☐ Drive along a curving mountain road
- ☐ Play games like Chess, Go, Bridge, Poker
- ☐ Discover and prove a new mathematical theorem
- ☐ Write an intentionally funny story
- ☐ Give competent legal advice in a specialized area of law
- ☐ Translate spoken English into spoken Swedish (or Chinese) in real time



# Summary

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- ❑ Artificial Intelligence has a long history in diverse areas of science as well as philosophy and literature
- ❑ Debates continue over the definition of Intelligence
- ❑ Significant progress has been made, but many challenges remain.

# References

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- ❑ Poole & Mackworth, Artificial Intelligence: Foundations of Computational Agents, Chapter 1
- ❑ Russell & Norvig, *Artificial Intelligence: a Modern Approach*, Chapter 1.