Richard W. Hamming

Learning to Learn

The Art of Doing Science and Engineering

Session 7: Artificial Intelligence II

Topic Outline

- Machines Complementing Mankind
- What is Thinking?
- Machines and Originality
- Machines Competing with Mankind
- AI Applications
- Fundamental Questions

Focus

More concerned with the aid computers can give us in *intellectual* areas than *mechanical* areas

- Manufacturing: better, preferable, cheaper products
- Essential in space flights, aircraft control

AI complementary to *robotics*: intellect versus physics

Commonalities

Components	Machines	Humans
Built from Atoms and Molecules	Yes	Yes
Basic Parts	State devices for storage and gates	Cells
Larger Structures	Arithmetic units Storage Control I/O	Bones Muscles Organs Blood vessels Nervous System

Key Ideas

From large organizations new effects can arise

When we engineer some device to do some thing Nature does, we do it differently

- Aircraft
- Wheels
- Nervous system versus computer signals

Thinking

Something the human brain can do.

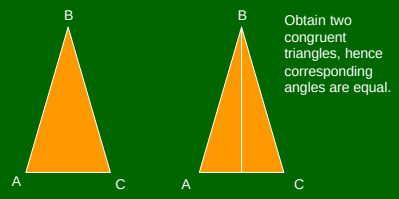
Is the failure of computers to think based on size, speed, etc?

Is thinking a new effect from enough small parts – thinking from non-thinking parts?

We do not know what thinking really is!

Geometry Theorem Proving

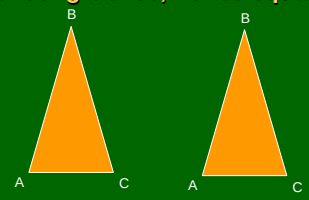
Problem: If two sides of a triangle are equal then the base angles are also equal.



Obtain two congruent triangles, hence corresponding angles are equal.

Machine Proof

Compared triangle ABC with triangle CBA to show selfcongruence, hence equal angles!



Did the program show "originality"??

Separating Us from Machines

Programmers gave the machine instructions so the ability was programmed in

Any different than when we were taught geometry by a teacher?

Did Samuel's checkers playing program show originality when it made surprising moves and defeated the State Checkers Champion?

What is the test we will use to separate us from a computer program?

Our Bias

Could say…

- Checkers playing program "learned"
- Geometry theorem proving program showed "originality" or "creativity"

However, once the program exists we regard it as nothing but a rote routine, not exhibiting creativity or originality.

From this perspective, there is no way the machine can demonstrate it can "think"!

Dilemma

Hard AI people claim man is only a machine, so anything people can do intellectually can be copied by a machine.

We often believe that because a machine was previously programmed, it cannot exhibit human intellect.

- Is this fair?
- Perhaps the whole world is merely molecule bouncing off molecule?

Music

Digital sampling and instrument replication

- Frequency
- Attack
- Synthesis

Composition

- Composers now have available any sound which can exist, at any rates, in any combinations, tempos, and intensities
- Immediate feedback to human composers

Recording: mixing and correction

The Point

Computers push us from the world of things to the world of ideas.

Computers supplement and extend what humans can do.

Interested in what man and computer can do together.

Computers Versus Humans

Computers can do many jobs better than humans and are replacing humans.

- e.g. robotics in manufacturing

Many humans are not equipped to compete with machines in these areas.

Very few people in the population can be trained to develop software.

Computers Versus Humans

No way to compare the number of people whose jobs are displaced (and the number provided new jobs) through computers.

- On average, lower-level jobs are disappearing and higher-level jobs are being created.
- Unclear that enough people can be trained to meet the higher-level demand.

Other AI Applications

Algebra-manipulating programs

- Depend on humans for guidance at various stages of the manipulation
- Difficulties in areas such as *simplification*

$$\frac{1}{\sqrt{x}}+\frac{1}{\sqrt{y}} \quad \text{versus} \quad \frac{\sqrt{xy}\,(\sqrt{x}+\sqrt{y})}{xy}$$

Which expression is in simplified form?

Synthesis of Chemical Compounds

Program provides

- Possible routes to the synthesis
- Costs
- Times of the reactions in the process
- Effective yields

Programmer can explore various ways of synthesizing a new compound, or else re-exploring old ones to find new methods

Medical Applications

Measurement of blood samples

Medical diagnosis

Over the long run, machines can probably do better than the average doctor, and it is average doctors that treat the majority of the people!

Legal Issues -- Culpability

Human doctors are protected by "due prudence" if they make a mistake in diagnosis.

If the machine errs, who is responsible (and therefore who can be sued)?

- Machine? Programmers? Experts who provided the rules?

Often the legal problems of new applications are the main difficulty, not the engineering!

Medical Profession

Computers do billing, scheduling and record keeping

Computers monitor patients

Doubtful that full-time nurses could equal the combination of computer and nurse

Other Abstract Symbol Manipulation Programs

Differentiation

Coordinate Conversion

- Extra degree of freedom in all radars so the target cannot fly over the end of an axis of rotation and force the radar to slew 180° to track it

Analytical Integration (Slagle, 1961, MIT)

- Improved versions able to find any integral that can be done in closed form, or prove it cannot exist

Computers Building Computers

Robot assembly of computer components and integrated packages

Integrated circuits

In restricted areas where there can be no surprises, robots are fairly effective, but where unexpected things can happen then simple robots are often in serious trouble

Navy Applications

Robots onboard ship (running on rails to avoid problems with obstacles?)

Damage Control

Remote Controlled Mine Sweepers

Current NPS Research – Autonomous Underwater Vehicles (AUVs) and Unmanned Aerial Vehicles (UAVs)

Game Playing

Chess – IBM's Big Blue defeated World Chess Champion Garry Kasparov May 11, 1997!

- Program examines millions of board positions per second compared to humans examining 50 to 100 before making a move (based on what psychologists think chess masters think!)

Generally, machines "solve the problem by volume of computations" rather than by "insight" (whatever "insight" is!)

Logical Versus Psychological Novelty

Discovery led by past experiences: Psychological Novelty

Discovery from independent insight: Logical Novelty

- Machines do not produce logical novelty when working properly
- Can a human produce logical novelty?
- Is logical novelty actually possible?

Random Source

Claim: A truly random source contains all knowledge

- Monkeys on typewriters!
- Can be obtained if you write a program to recognize "information"

But, the wait time is too long and you cannot always recognize "information" when you see it!

Free Will

Claim: Free will is a myth, in a given circumstance you being you as you are at the moment you can only do as you do.

- What experiment would you perform to prove or disprove this?

Often accept belief in free will in ourselves, but deny it for others!

Can Machines Think?

Perhaps thinking should be measured not by what you do but how you do it.

- Child learning how to multiply versus adult performing multiplication

"Hard AI" people accept only what is done as a measure of success, and computers have not measured up by the results

Can Computers Think?

We want to believe so machines could help us in our mental world

We want to disbelieve to preserve our feeling of self-importance

Main sticky points:

- If a machine does it then it must be an algorithm and cannot be thinking!
- By what forces do our thinking, self-awareness, and self-consciousness affect the paths of molecules if everything is just molecule banging against molecule?

Related topics

David B. Fogel, Blondie24: Playing at Edge of AI, Morgan Kaufman Publishers, San Francisco, 2002.

- Excellent little book on the topic of machine intelligence through game-playing examples (great discussion of Chess and Checkers)

  http://www.digenetics.com/company/blondie24.htm

- See also the following interview with current World Chess Champion Vishwanathan Anand of India

  http://www.time.com/time/asia/features/interviews/2001/01/09/int.kasparov.html