

The Power of Computers

Speed, not Smarts

February 2011

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Blazing Speed

- Computers need not be smart as long as they are fast. Breaking the Enigma code could have been done by humans, but it would have taken too long for the result to be useful.
- Credit cards are the most visible effect of computers in everyday life. It could take a person several minutes to record a card transaction but with a computer the transaction can be completed in a fraction of a second.

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Evolution of Speed

- Early computers (in the 1940's) could perform around **several thousands** of machine instructions per second (MIPS).
- Today, your ordinary laptop or desktop can perform **several billions** of MIPS.
- The 1948 IBM SSEC machine performed "only" 50 multiplications per second.
- My desktop *Dell* computer (vintage 2002) has a Pentium processor that can execute one billion integer multiplications per second.

Moore's Law

- Computer memory has also been increasing, even faster than speed. Gordon Moore, one of the founders of Intel, wrote in 1966 that the number of transistors that could be packed in given size of silicon would double every two years. The prediction proved accurate and it is has been called *Moore's law*.
- My desktop has 768 Megabytes of RAM (**R**andom **A**ccess **M**emory) while the first personal computers thirty years ago had only 64 Kilobytes, so we have seen an increase in RAM size of about 10,000 in 30 years. ($2^{15} = 32,768$)

Hard Drive Capacity

Year	Capacity in Bytes	Capacity in Pictures or Books
1980	one Megabyte (10^6)	one
1990	100 Megabytes (10^8)	100
2000	10 Gigabytes (10^{10})	10,000
2010	1000 Gigabytes (10^{12})	one million

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A Bit of History

Year	Event
1971	First e-mail (over Dept. of Defense network ARPAnet)
1981	First portable computer (Osborne)
1983	ARPAnet opened for civilian use. Renamed <i>Internet</i> in 1995.
1985	Programming Language C++

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THE SEMANTIC GAP

Numbers and Text versus Everything Else: Speech, Music, Pictures

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The Root of the Problem - 1

- Pictures are also stored as strings of numbers, the colors at each **pixel**.
- The word pixel stands for picture element and here we come into the first fundamental difference between text and pictures.
- Pixels have no meaning for humans

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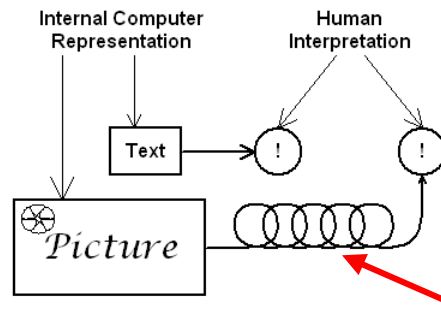
The Root of the Problem - 2

- The characters in a text are natural elements and they describe the text whether stored in computer memory or chiseled in a stone tablet.
- If you know how to read, the sequence **fox** conveys the concept of an animal with, usually, brown fur and a long tail.
- At the same time characters are mapped into numbers (**102 111 120** for fox) that are easily processed by a computer.

The Root of the Problem - 3

- When a picture is taken with a digital camera, it is subdivided into tiny areas and information about their color is stored in the camera memory and, eventually, in computer memory. These tiny elements are the pixels. Because any color can be expressed as a combination of red, green, and blue, for each pixel we store the values of these three colors.
- The trouble is that pixels have no meaning for humans. One must create from them other entities that capture properties of a picture that are meaningful to people and that is not an easy task.

The Semantic Gap Illustrated



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A Reminder from Biology

- The human visual system has evolved from animal visual systems over a period of more than 100 million years (dinosaurs had a good visual system).
- Speech is barely over 100 thousand years old and written text no more than 10 thousand years old.
- On that basis, it seems that pictures would represent a much more difficult challenge for computers than speech, and speech in turn would be more challenging than text.

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Bibliography

- V. S. Ramachandran and S. Blakeslee, *Phantoms in the Brain*, William Morrow and Company Inc., New York, 1998.
 - Chapter 4 is the most pertinent.