CS109  Computer Science
Lecture One

Where we’ve come so far…

What is Computer Science and why does it matter?

Computer Science = Science of Information

Digital vs Analog Information

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October 21st, 2016
What have we done so far?

- Well…. Lots of math:
- Describe reality using numbers and symbols
- Find out new stuff using proofs and manipulations of numbers and symbols using rules

Population distribution:
\[ \mu = 15, \sigma = 4 \]

Sampling distribution of \( x \):
\[ N(\mu, \sigma/\sqrt{n}) = N(15, 4/8) \]

\[ n = 64 \]

\[ \sigma_x = 4/\sqrt{64} = 4/8 \]
N=64 account executives are randomly selected. What is the probability that the sample mean exceeds $20,500?

answer \( E(x) = $20,000, \ SD(x) = $5,000 \)

\[
E(\bar{x}) = $20,000, \ SD(\bar{x}) = \frac{SD(x)}{\sqrt{n}} = \frac{5,000}{\sqrt{64}} = 625
\]

By CLT, \( \bar{X} \sim N(20,000, 625) \)

\[
P(\bar{X} > 20,500) = P\left( \frac{\bar{X} - 20,000}{625} > \frac{20,500 - 20,000}{625} \right) =
\]

\[
P(z > .8) = 1 - .7881 = .2119
\]
Let’s take another look...

- “Describe reality” = give information
- “numbers and symbols” = encode information
- “proofs and manipulations” = calculation
- “… using rules” = using an exact step by step description of a process
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- Algorithm = “exact, step by step description of a process”
Let’s take another look…

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- “proofs and manipulations” = calculation
- “… using rules” = using an exact step by step description of a process
- Algorithm = “exact, step by step description of a process”
- Computation = “applying an algorithm to manipulate information”
So what have we done (version 2.0)?

Well…. computation!

- We encoded information about the world using symbols
- We applied algorithms to derive new information, also represented as symbols:

N=64 account executives… etc.

CS 109 Student

0.234 !
What will we do for rest of semester....

Well.... computation!

- We will encode information about the world using symbols
- We will apply algorithms to derive new information, also represented as symbols
- The difference is that we will think about how to do this with a computer running the algorithm!
What will we do for rest of semester....

Well.... computation!

- We will encode information about the world using symbols
- We will apply algorithms to derive new information, also represented as symbols
- The difference is that we will think about how to do this with a computer running the algorithm!
- Because humans are smart but slow, and computers are dumb but fast, there will be some differences in our approach: we will have to be much more specific about all the details of the process.....
Agenda for rest of the term:

- What is information and how can we describe it in symbols?
- What is an algorithm? How do computers execute algorithms?
- What can algorithms do?
- What can’t algorithms do?
- What are the big ideas of Computer Science we should know about?
- Where will this all end? Where are we headed? Will there be a Singularity???
What is Information?

- **Wikipedia:** “*Information* in its most restricted technical sense is a message (utterance or expression) or collection of messages that consists of an ordered sequence of symbols, or it is the meaning that can be interpreted from such a message or collection of messages.”

- **Shorter:** “Information is the absence of randomness”

- Remember flipping a coin being a random experiment? When you looked at the coin to see heads or tails, the randomness was replaced by information....

- But information is a slippery thing, and basically has two forms..... Analog and Digital
Analog information is information about the real world.....
Information: Analog vs Digital
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Digital Information is information contained in symbols:
Digital Information

You can’t zoom in on a symbol and get more information: it has a fixed meaning that never changes
And you can’t get a part of the meaning by just looking at a part of the symbol; it is “all or nothing”
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Digital Information

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Question: When is it a symbol and when a picture?

<table>
<thead>
<tr>
<th>Egyptian</th>
<th>Cretan</th>
<th>Phoenician</th>
<th>Semitic</th>
<th>Greek Alpha</th>
<th>Etruscan</th>
<th>Roman/Cyrillic</th>
<th>Boeotian 800–700 BC</th>
<th>Greek Uncial</th>
<th>Latin 300 AD Uncial</th>
</tr>
</thead>
<tbody>
<tr>
<td><img src="image1" alt="Egyptian" /></td>
<td><img src="image2" alt="Cretan" /></td>
<td><img src="image3" alt="Phoenician aleph" /></td>
<td><img src="image4" alt="Semitic" /></td>
<td><img src="image5" alt="Greek Alpha A" /></td>
<td><img src="image6" alt="Etruscan A" /></td>
<td><img src="image7" alt="Roman/Cyrillic A" /></td>
<td><img src="image8" alt="Boeotian 800–700 BC" /></td>
<td><img src="image9" alt="Greek Uncial" /></td>
<td><img src="image10" alt="Latin 300 AD Uncial" /></td>
</tr>
</tbody>
</table>
One Simple fact: All symbolic information can be expressed as bits (0 or 1)

A = 65 = 1000001
Analog vs. Digital Information

Summary:

Analog Information is continuous information about the real world, any piece containing in principle an infinite amount of information;

Digital Information is discrete information represented by symbols, each of which represents one indivisible unit of information.

\[ \pi = 3.14159265358979 \ldots \]
The most important thing to realize about digital information is that the appearance of the symbols is arbitrary, and for the purposes of computation all symbols can be replaced by numbers, and all numbers can be represented by bits (0 or 1):

\[ A = 65 = 1000001 \]

In lab you will study binary numbers in more detail, but let’s take a preliminary look
Numbering Systems

A numbering system assigns meaning to the position of the numeric symbols.

For example, consider this set of symbols:

642

What number is it? Why?
Numbering Systems

It depends on the numbering system.

642 is 600 + 40 + 2 in BASE 10

The base of a number determines the number of digits (e.g. symbols) and the value of digit positions.
Continuing with our example…

642 in base 10 *position notation* is:

\[
6 \times 10^2 = 6 \times 100 = 600 \\
+ 4 \times 10^1 = 4 \times 10 = 40 \\
+ 2 \times 10^0 = 2 \times 1 = 2 \\
= 642 \text{ in base 10}
\]

This number is in base 10, because we have 10 fingers!

The power indicates the position of the number.
What base would Pooh Use?
As we have discussed, the simplest number system uses only two digits.

Binary numbers are built by concatenating a string of bits together.
Example: 10101010
Recall this general form:

\[ d_n \cdot B^{n-1} + d_{n-1} \cdot B^{n-2} + \ldots + d_1 \cdot B^0 \]

The same can be applied to base-2 numbers:

\[ 1011_{\text{bin}} = 1 \cdot 2^3 + 0 \cdot 2^2 + 1 \cdot 2^1 + 1 \cdot 2^0 \]
\[ 1011_{\text{bin}} = (1 \cdot 8) + (0 \cdot 4) + (1 \cdot 2) + (1 \cdot 1) \]

\[ 1011_{\text{bin}} = 8 + 0 + 2 + 1 = 11_{\text{dec}} \]
What is the decimal equivalent of the binary number 01101101?

(you try it! )
What is the decimal equivalent of the binary number 01101101?

\[
egin{align*}
0 \times 2^7 & = 0 \times 128 = 0 \\
+ 1 \times 2^6 & = 1 \times 64 = 64 \\
+ 1 \times 2^5 & = 1 \times 32 = 32 \\
+ 0 \times 2^4 & = 0 \times 16 = 0 \\
+ 1 \times 2^3 & = 1 \times 8 = 8 \\
+ 1 \times 2^2 & = 1 \times 4 = 4 \\
+ 0 \times 2^1 & = 0 \times 2 = 0 \\
+ 1 \times 2^0 & = 1 \times 1 = 1 \\
\end{align*}
\]

= 109 (decimal)
### Counting in Binary

*Now we can see how to count in binary:*

<table>
<thead>
<tr>
<th>Decimal</th>
<th>Binary</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>2</td>
<td>10</td>
</tr>
<tr>
<td>3</td>
<td>11</td>
</tr>
<tr>
<td>4</td>
<td>100</td>
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<tr>
<td>5</td>
<td>101</td>
</tr>
<tr>
<td>6</td>
<td>110</td>
</tr>
<tr>
<td>7</td>
<td>111</td>
</tr>
<tr>
<td>8</td>
<td>1000</td>
</tr>
<tr>
<td>9</td>
<td>1001</td>
</tr>
<tr>
<td>10</td>
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</tr>
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</table>

Think Odometer with two digits!