Bits and sizes

Last time covered amounts of information.
Let’s practice.
**Brain complexity**

Brain is a network of cells connected together
Connections have strength that may store memory

**Details**

100 billion neurons
5000 connections per neuron
1 Byte to represent connection strength
Calculation 1 – only strengths matter

100 billion neurons
8000 connections per neuron
1 Byte to represent connection strength

How much information?
A. 128 MB
B. 100 GB
C. 800 GB
D. 100 TB
E. 800 TB

Calculation 2 – info in pattern of connections

100 billion neurons
8000 connections per neuron
1 Byte to represent connection strength
4 Bytes to represent where connection goes

How much information?
A. 3200 GB
B. 4 TB
C. 500 TB
D. 3200 TB
E. 4000 TB
Comparison – size of the web

How many unique documents
  • Nobody really knows
  • Trillions of URLs
  • Many auto or duplicate pages
  • Rough guess: 100 billion

Average size per page
  • 300 KB
  • Remember: text, images, sound, etc.

Calculation

100 billion pages
300 KB per page

Total data:
A. 300 TB
B. 3000 TB
C. 30,000 TB
D. 300,000 TB
E. 3 M TB
Comparison again

Your brain: 4000 TB (or more)
The whole web: 30000 TB (at most)

Lots of info in the room!

Using bits to decide what to do

Describe a complex task in terms of steps
  • Condition to look for in the world
  • Action to take if the condition is true

Implement condition in terms of bits
  • Boolean algebra
  • Logic blocks
**Boolean algebra**

Variables stand for bits – conditions in the world

- $p = \text{true}, \ q = \text{false}$

Build expressions for other conditions

- And (conjunction): $p \ and \ q$
- Or (disjunction): $p \ or \ q$
- Not (negation): not $p$

Write equations describing relationships

- $p \ and \ q = q \ and \ p$

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**Follow the rules #1**

When is it OK to be in an R movie? You are 17-or-older or you have an adult guardian with you.

- $x$: person is 17 or older
- $y$: person is accompanied by an adult guardian
- $x \ or \ y$: person can see an R rated movie
"Or" examples

Bill is 22 and is seeing the movie with his stepdad
  • $x = \text{true}, y = \text{true}, x \text{ or } y = \text{true}$
Samantha is 17 and is seeing the movie alone
  • $x = \text{true}, y = \text{false}, x \text{ or } y = \text{true}$
Seth is 16 and is there with both of his parents
  • $x = \text{false}, y = \text{true}, x \text{ or } y = \text{true}$
Jessica is 13 and is there with friends from school
  • $x = \text{false}, y = \text{false}, x \text{ or } y = \text{false}$

Follow the rules #2

To be President, you have to be 35 years or older and have been born in the USA.

$x$: person is 35 years old or older
$y$: person was born in the USA
$x$ and $y$: person is eligible to run for President
“And” Examples

Barack is 47 and was born in Hawaii
  • $x = \text{true, } y = \text{true, } x \text{ and } y = \text{true}$
Arnold is 61 and was born in Austria
  • $x = \text{true, } y = \text{false, } x \text{ and } y = \text{false}$
Britney is 27 and was born in Louisiana
  • $x = \text{false, } y = \text{true, } x \text{ and } y = \text{false}$
Amy is 25 and was born in London
  • $x = \text{false, } y = \text{false, } x \text{ and } y = \text{false}$

Follow the rules #3

It is not allowed by Federal law to provide tobacco products to person under 18 years of age

$x$: person is under 18
not $x$: person can buy tobacco
“Not” Examples

Samantha is 17 and is interested in cigarettes
• $x = \text{true, not } x = \text{false}$
Seth is 21 and purchased a cigar
• $x = \text{false, not } x = \text{true}$

And, Or, Not

The most important logical operations are and, or, and not.
• $x$ and $y$ is true exactly when both $x$ and $y$ are true
• $x$ or $y$ is true exactly when either $x$ or $y$ is true
• not $x$ is true exactly when $x$ is false

A lot like their English meanings, but unambiguous
Relating And, Or, Not

not (not x) = x

not (x and y) = (not x) or (not y)

not (x or y) = (not x) and (not y)

De Morgan's Law
Example with DeMorgan’s Law

x: Rob can juggle
y: Rob can ride a unicycle
not (x and y): Rob is not a juggling unicyclist
   (It’s not the case that Rob can both juggle and ride a unicycle.)

Equivalently:
(not x) or (not y): Either Rob can’t juggle or Rob can’t ride a unicycle

Specifying processes with Boolean logic

Tic-tac-toe
• Bits describe what moves have been made
• Conditions describe what moves to make
• Write conditions in Boolean algebra from bits
Specifying processes with Boolean logic

Tic-tac-toe

Assume we play first, and move at upper left.
Tic-tac-toe

Maybe opponent plays center as first move. We respond at upper right.

Tic-tac-toe

Maybe opponent plays top center as second move. We respond at bottom center.
Tic-tac-toe

Variables:
• x-top-left-1
• o-center-1
• x-top-right-2
• o-top-center-2
• x-bottom-center-3

Description of this specific play:
• x-top-left-1 = true
  move top left first
• o-center-1 = x-top-right-2
  o moves center as first, and so
  x moves top right next
• o-center-1 and o-top-center-2 = x-bottom-center-3
  o moves center as first and top center as second
  and so x moves bottom center next
Game Tree

Map everything opponent could do
• with our responses

All possible situations after step 2
Step 2 – first case

\[
\begin{array}{ccc}
X & X & X \\
O & & O \\
O & & O
\end{array}
\]

Step 2 – second case

\[
\begin{array}{ccc}
X & O & X \\
X & & X \\
X & O & X \\
O & X & O
\end{array}
\]
Step 2 – third case

\[
\begin{array}{cc}
X & X \\
X & O \\
X & O \\
\end{array}
\]

Rules for all branches of game tree

Step 2:
- o-center-1 or o-bottom-left-1 = x-top-right-2
  exactly when o moves center or bottom left as first,
  x moves top right next
- o-top-center-1 or o-bottom-center-1 or
  o-center-left-1 or o-center-right-1 = x-center-2
  exactly when o moves on a middle outside square,
  x moves center next
- o-top-right-1 or o-bottom-right-1 = x-bottom-left-2
  exactly when o moves top right or bottom right,
  x moves bottom left
Using bits to decide what to do

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Specifying processes with Boolean logic

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  • Bits describe what moves have been made
  • Conditions describe what moves to make
  • Write conditions in Boolean algebra from bits
Building Boolean logic

Lots of physical devices can be described with Boolean expressions

Let’s look at some examples

Simple circuits – bits, and, or
Simple circuits – bits, and, or

Symbols:
- Battery
- Ground
- Switch (off)
- Light (off)

Simple circuits – bits, and, or

Symbols:
- Battery
- Ground
- Switch (on)
- Light (on)
Simple circuits – bits, and, or

Use variable A for switch
Use variable L for light

When A is on, L is on
When A is off, L is off

A = L

http://scratch.mit.edu/projects/cs105/35907

Multiple switches

A and B are in series
Both must be on to turn on light L
L = A and B

http://scratch.mit.edu/projects/cs105/35909
Multiple switches

A and B are in parallel
Either can turn on light L
L = A or B

http://scratch.mit.edu/projects/cs105/35905