CS UNPLUGGED

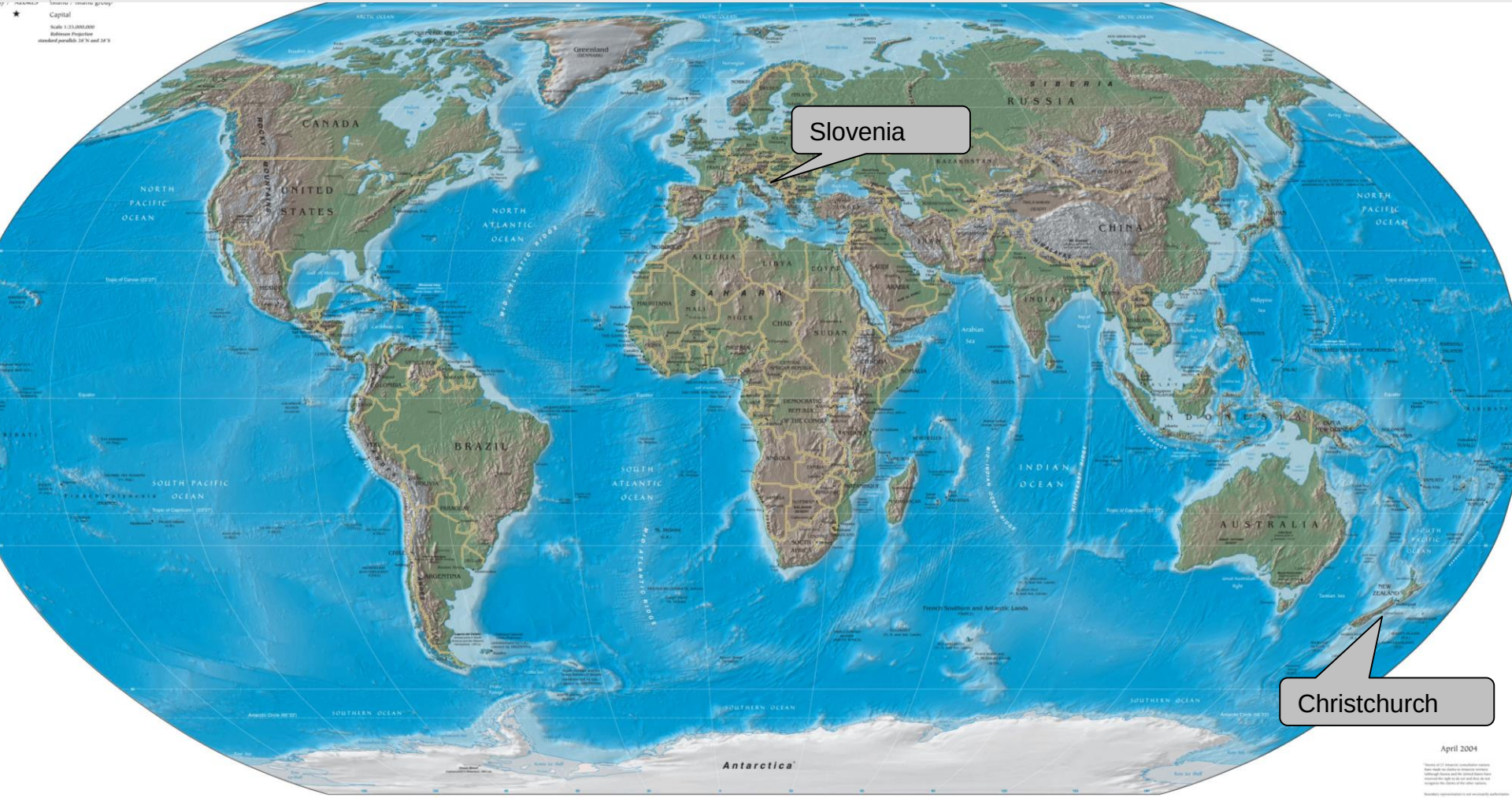
Computer Science... what's the big idea?

Tim Bell

University of Canterbury

Christchurch, New Zealand

UC UNIVERSITY OF CANTERBURY
Te Whare Wānanga o Waitaha
CHRISTCHURCH NEW ZEALAND


Slovenia
Christchurch
Capital
Scale 1:35,000,000
Robinson Projection
standard parallels 38°N and 38°S
Greenland
CANADA
ROCKY MOUNTAINS
NORTH PACIFIC OCEAN
UNITED STATES
NORTH ATLANTIC OCEAN
MID-ATLANTIC RIDGE
SIBERIA
RUSSIA
KAZAKHSTAN
MONGOLIA
CHINA
NORTH PACIFIC OCEAN
ALGERIA
LIBYA
EGYPT
SAUDI ARABIA
IRAN
IRAQ
INDIA
SAHARA
MAURITANIA
MALI
NIGER
CHAD
SUDAN
Arabian Sea
Philippine Sea
INDONESIA
BRAZIL
COLOMBIA
BOLIVIA
PARAGUAY
CHILE
ARGENTINA
SOUTH PACIFIC OCEAN
SOUTH ATLANTIC OCEAN
INDIAN OCEAN
AUSTRALIA
NEW ZEALAND
SOUTH PACIFIC OCEAN
French Southern and Antarctic Lands
SOUTHERN OCEAN
SOUTHERN OCEAN
Antarctica
April 2004

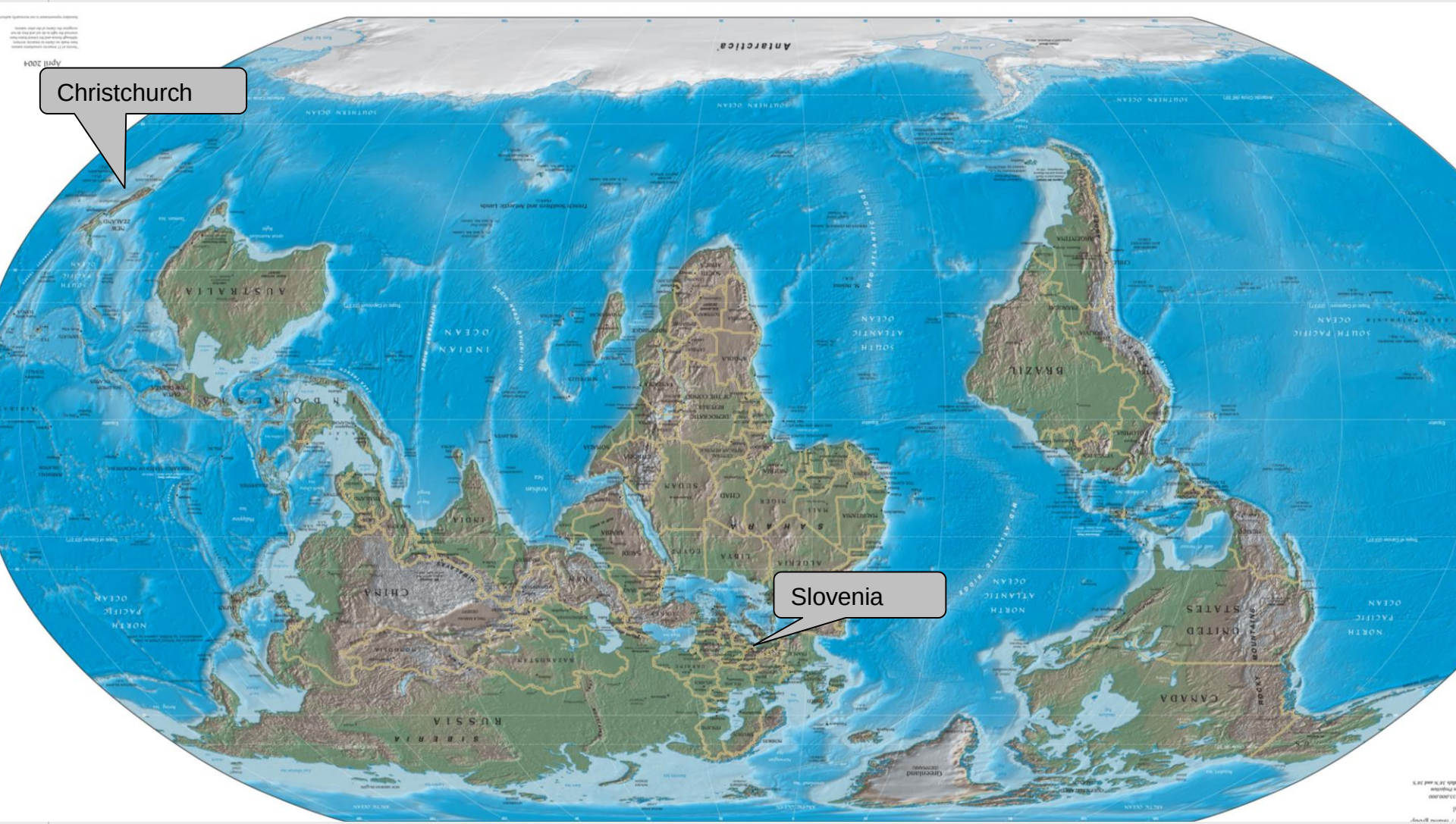

Christchurch
Slovenia

Photo: Roy Sinclair
http://welcomeaboard.co.nz/blog/quaint-grocery-returns/

Example: Giving change

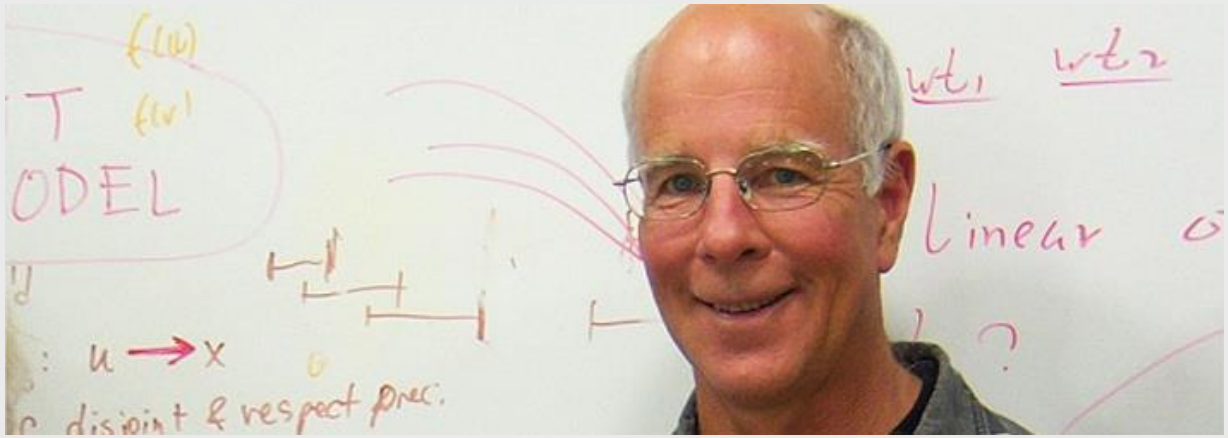
$75 change?

Automated change

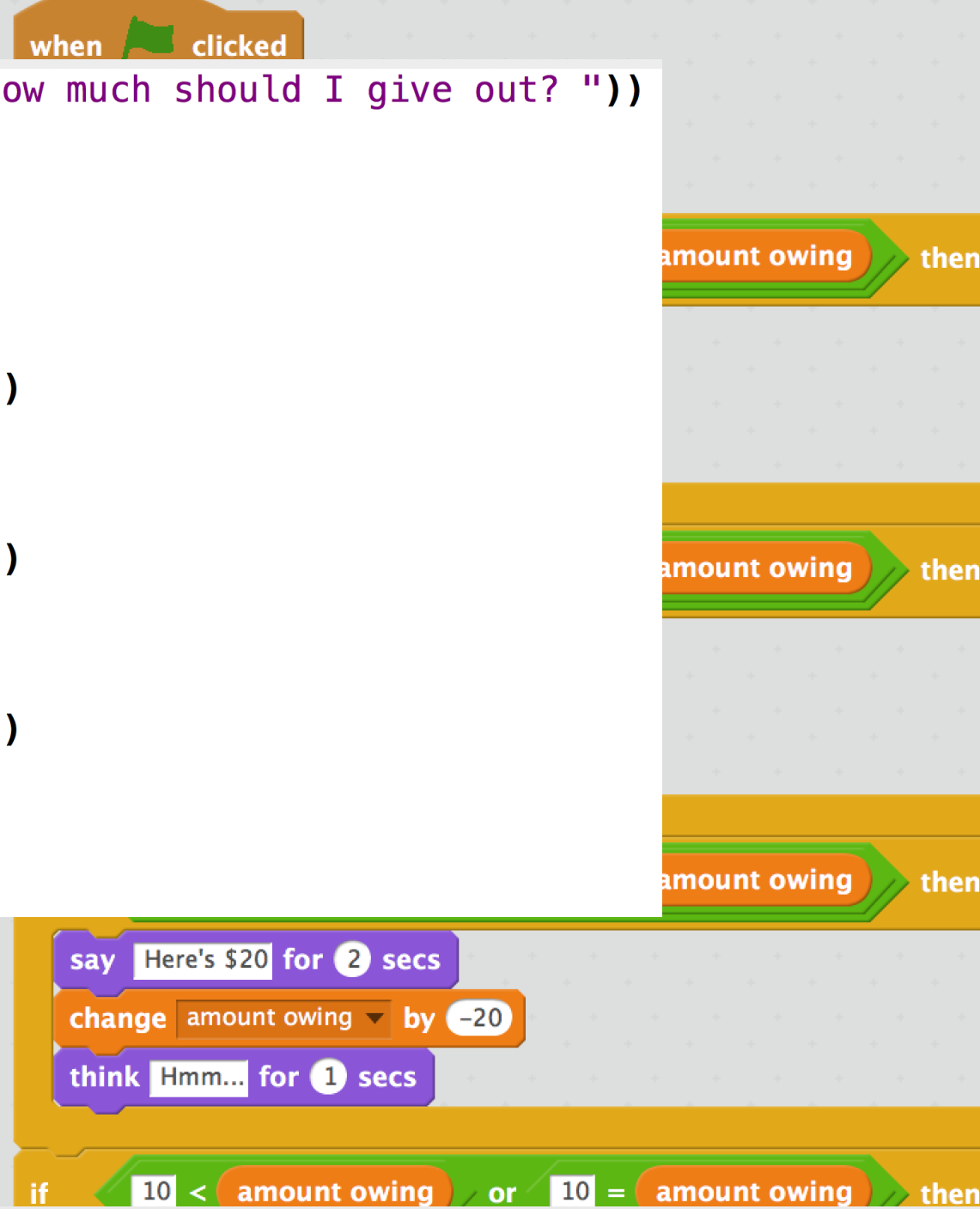
http://www.stuff.co.nz/the-press/technology/the-box/the-ball/297404/Scan-pack-and-pay

"Computer science is as much about programming as astronomy is about telescopes"

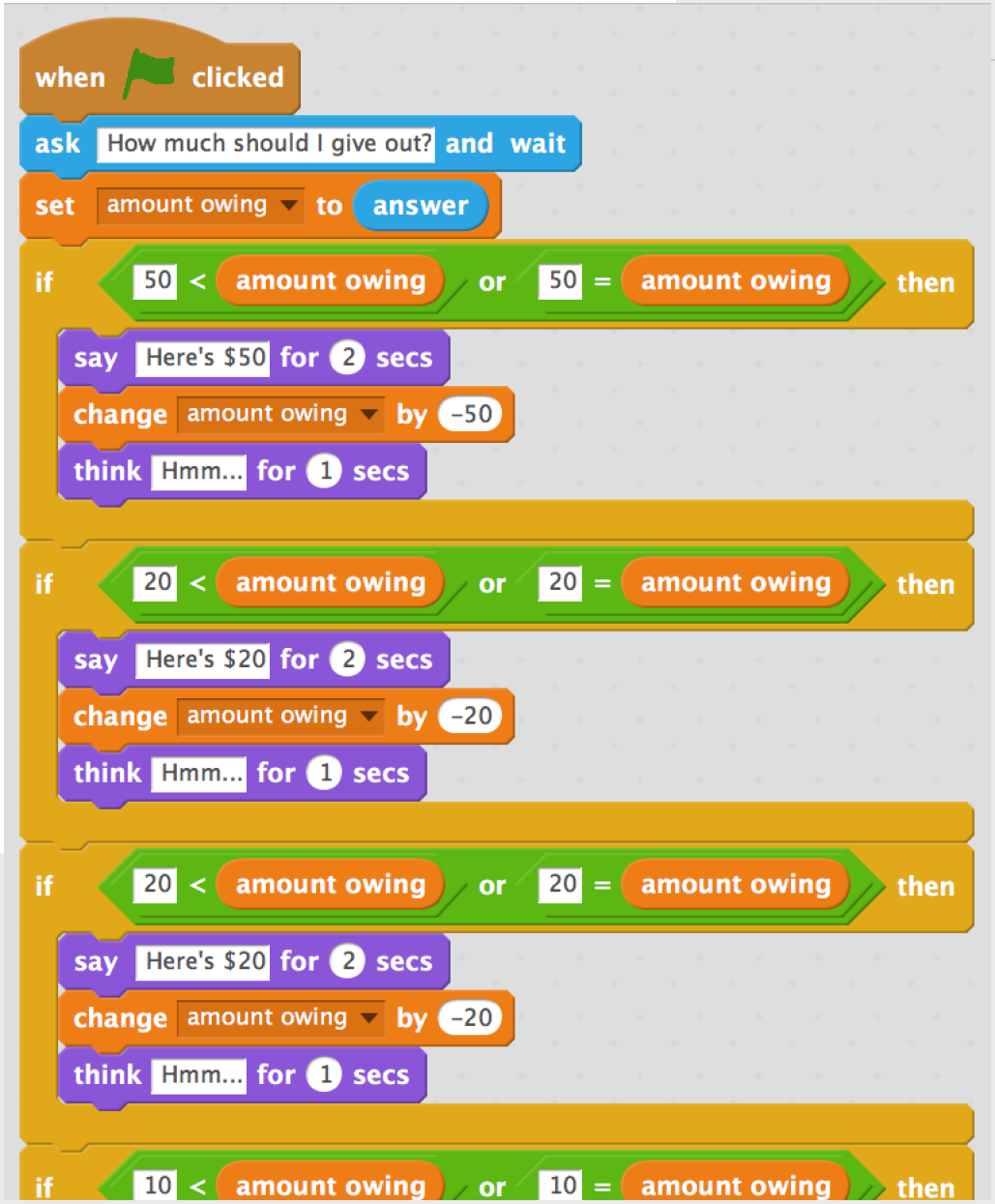
Mike Fellows



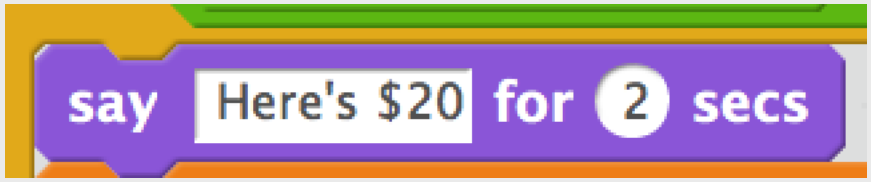
```
amount_owing = int(input("How much should I give out? "))

if 50 <= amount_owing:
    print("here is $50")
    amount_owing -= 50

if 20 <= amount_owing:
        print("here is $20")
        amount_owing -= 20

if 20 <= amount_owing:
        print("here is $20")
        amount_owing -= 20

if 10 <= amount_owing:
        print("here is $10")
        amount_owing -= 10

if 5 <= amount_owing:
        print("here is $5")
```



```
1  amount_owing = int(input("How much should I give out? "))
2
3  if 50 <= amount_owing:
4      print("here is $50")
5      amount_owing -= 50
6
7  if 20 <= amount_owing:
8          print("here is $20")
9          amount_owing -= 20
10
11 if 20 <= amount_owing:
12         print("here is $20")
13         amount_owing -= 20
14
15 if 10 <= amount_owing:
16         print("here is $10")
17         amount_owing -= 10
18
19 if 5 <= amount_owing:
20         print("here is $5")
```



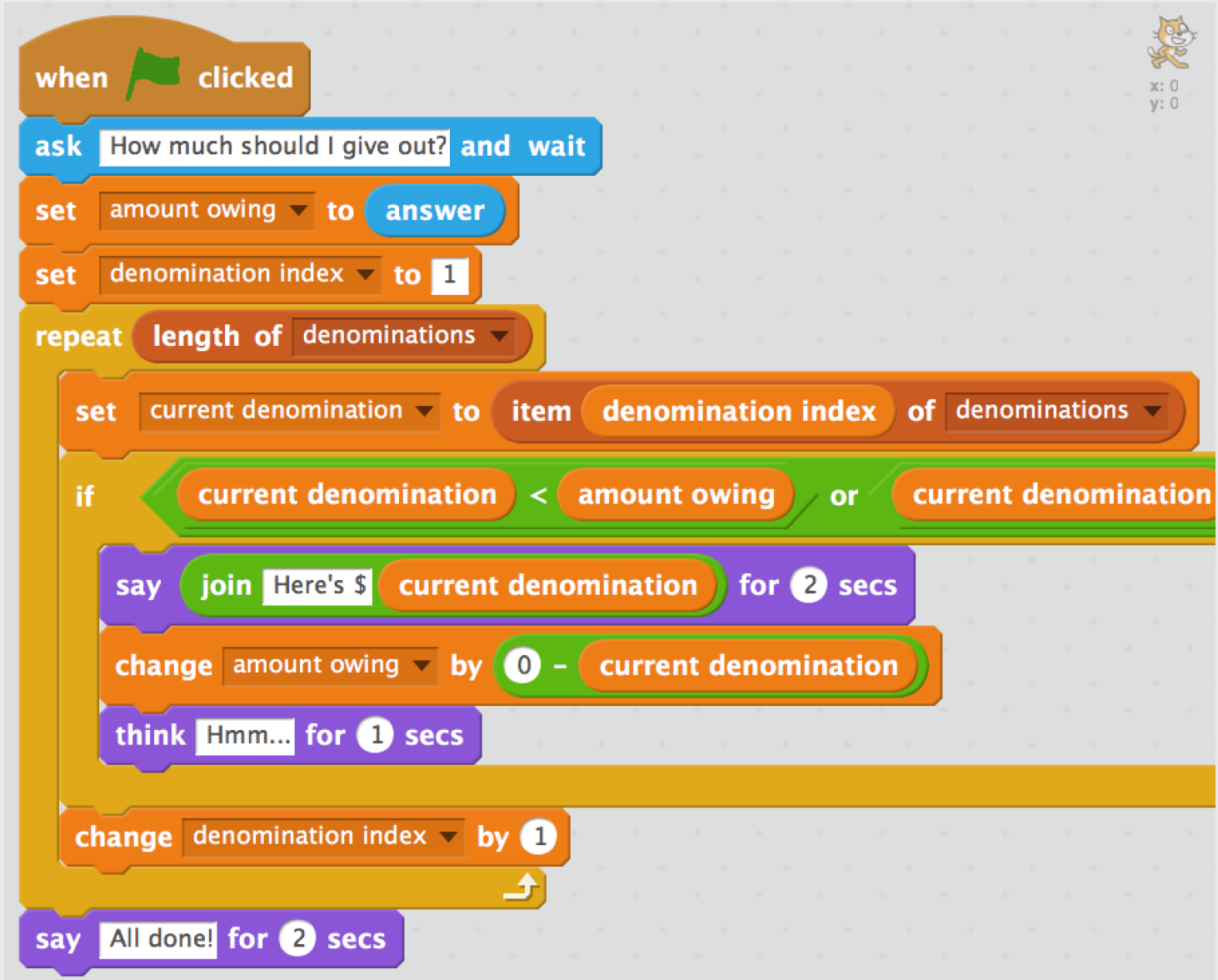
Output



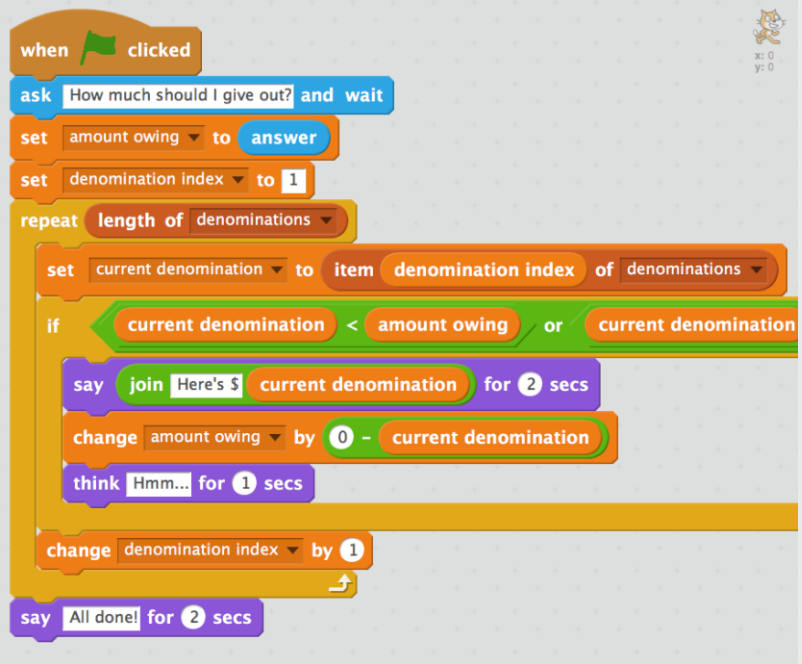

```
print("here is $20")
```

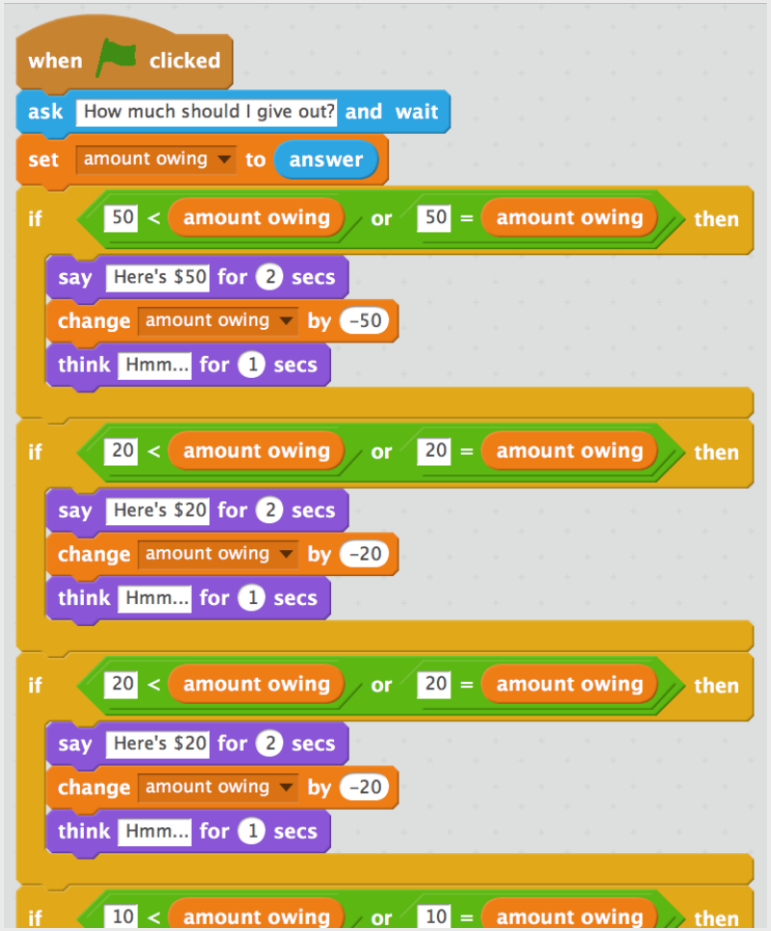
Teletypewriter, by Arnold Reinhold - Own work, CC BY-SA 3.0, https://commons.wikimedia.org/w/index.php?curid=31105488

Using iteration…

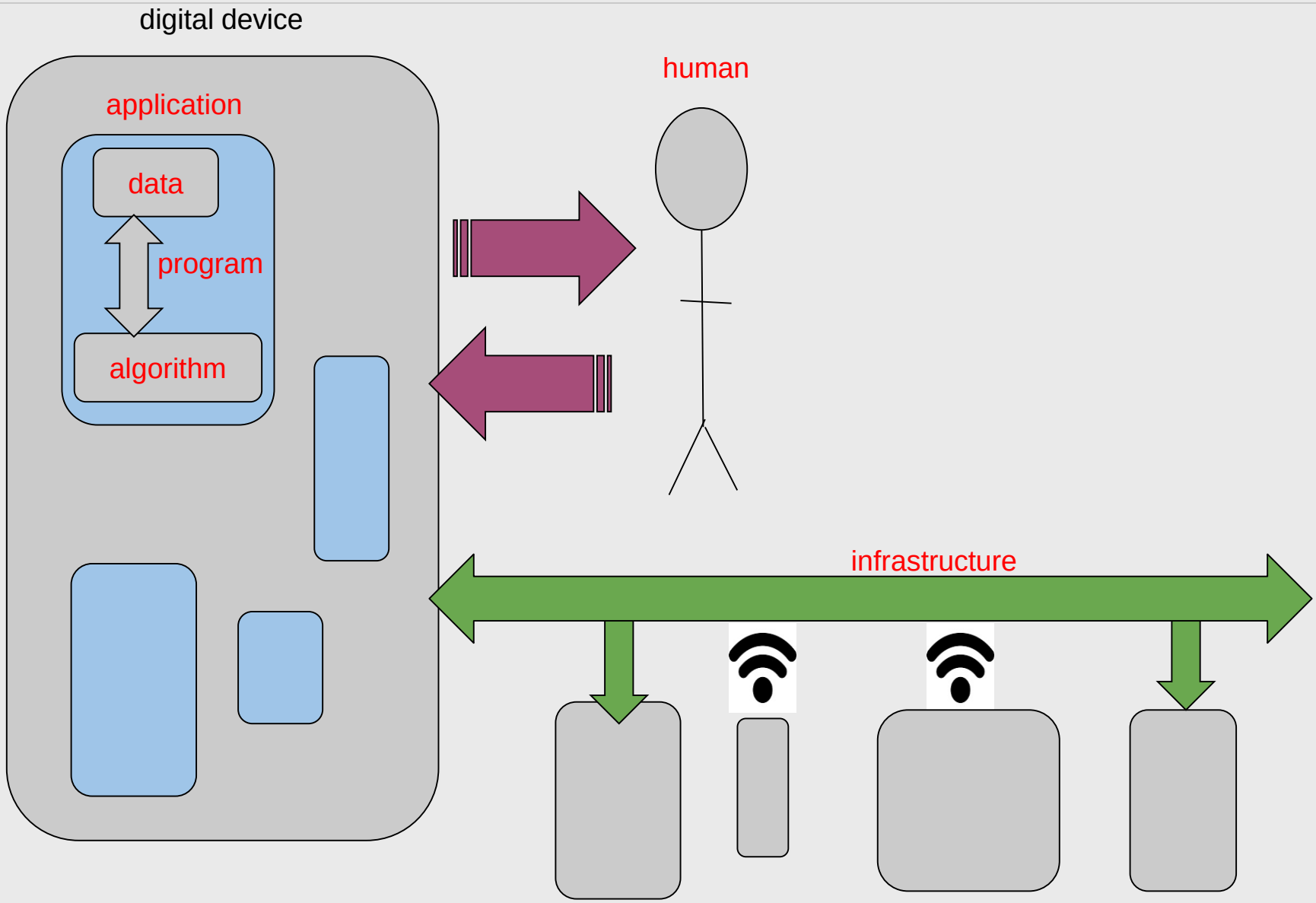


There's no single correct answer…



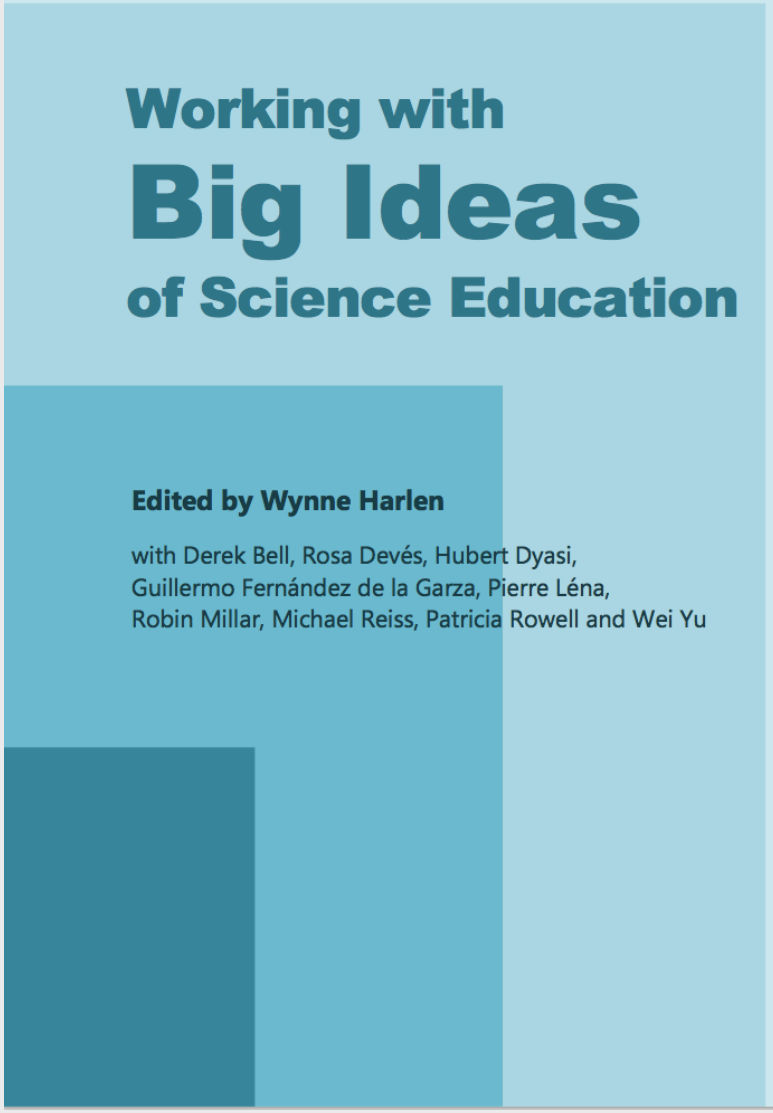


Structure of Digital Technologies



Your digital day

- Shopping
- Finance
- Transport
- Entertainment
- Privacy/security
- Fitness



the key ideas that students should encounter in their science education to enable them to understand, enjoy and marvel at the

natural world

- to respond to students' perceptions of science as a **fragmented collection of facts** and theories of little relevance to them,
- help students to **explain things they find important**
- basis for **selection** from the **enormous range** of possible **curriculum content**
- inform the development of curriculum frameworks built on **progression towards big ideas**

λ?

the key ideas that students should encounter in their computing education to enable them to understand, enjoy and marvel at the

digital world

http://www.cosc.canterbury.ac.nz/research/RG/CSE/big-ideas/

https://goo.gl/mWXchU

The big ideas in CS/CT

1. **Data** is represented in digital form on a computer.
2. **Algorithms** interact with data to solve computational problems.
3. The **performance** of algorithms can be modelled and evaluated.
4. Some computational problems **cannot be solved** by algorithms.
5. **Programs** express algorithms and data in a form that can be implemented on a computer.
6. Computing systems are designed by **humans** to serve human needs.
7. Computing systems create **virtual** representations of natural and artificial phenomena.
8. **Protecting** data and system resources is critical in computing systems.
9. **Time dependent** operations in computing systems must be coordinated.
10. **Protocols** facilitate communication between computing systems.

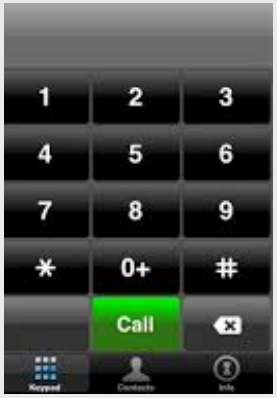
http://www.cosc.canterbury.ac.nz/research/RG/CSE/big-ideas/

Data is represented in digital form

on a computer

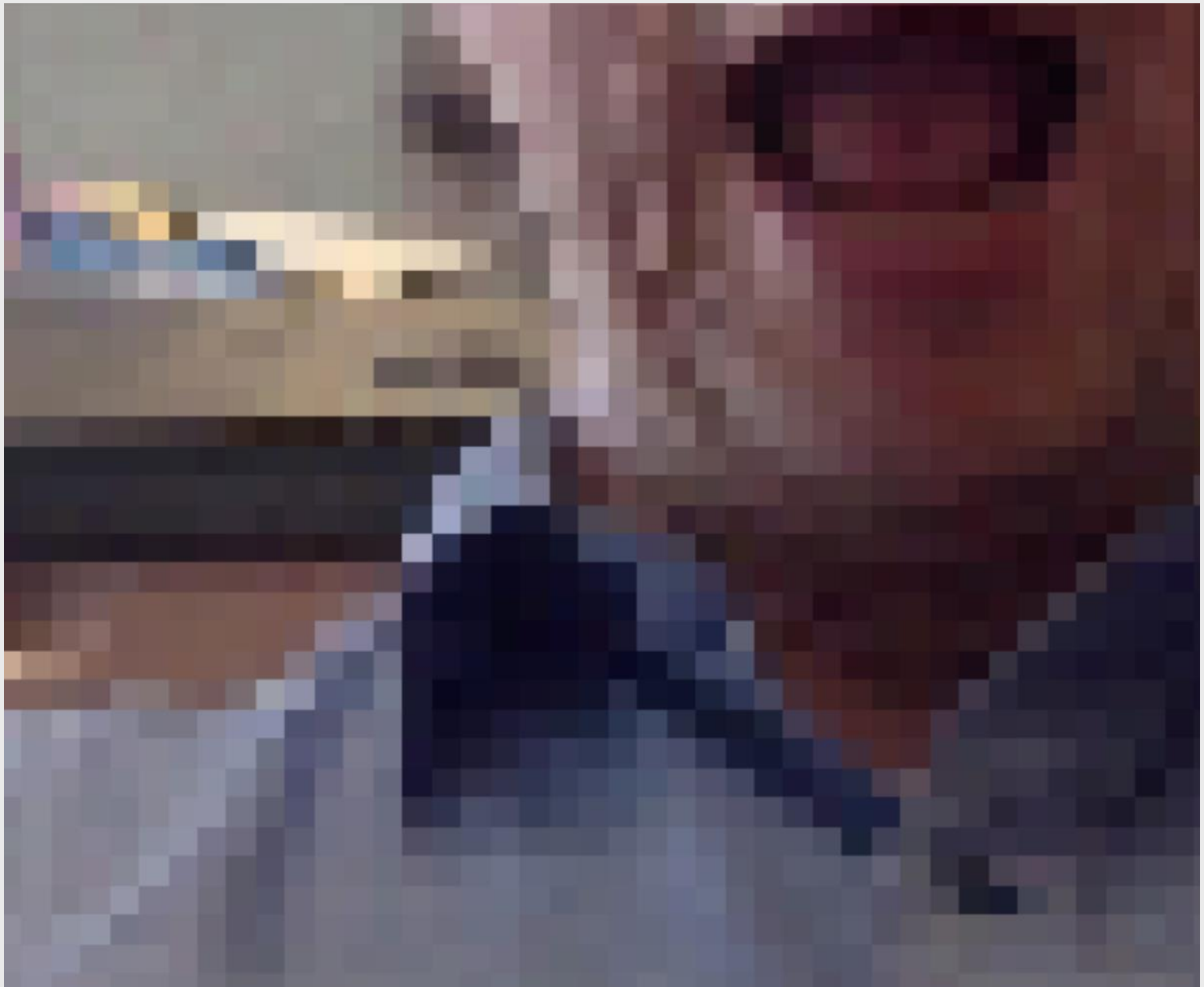
0 1

It’s all digital!

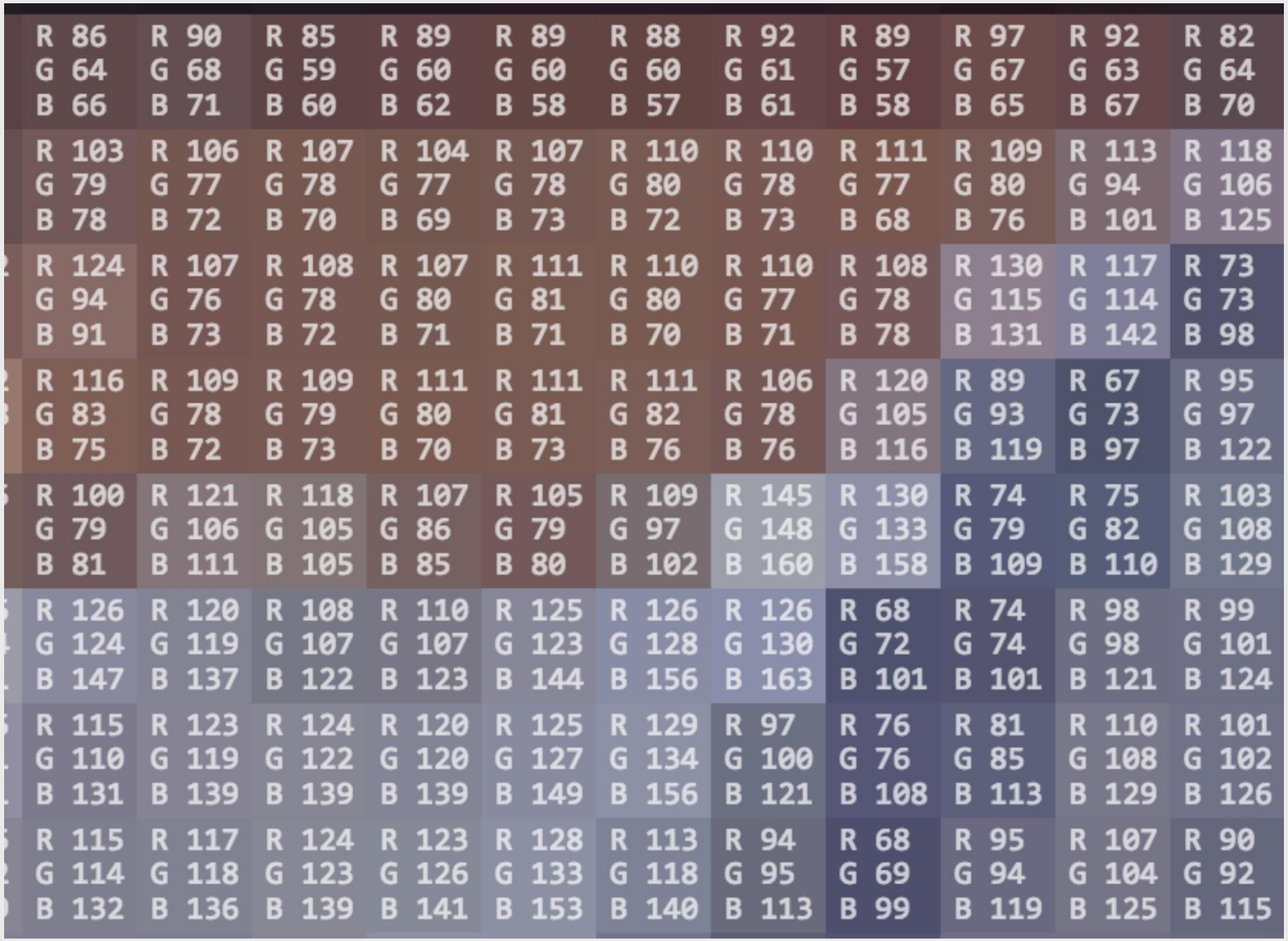


Digital technologies?

Digital technologies?

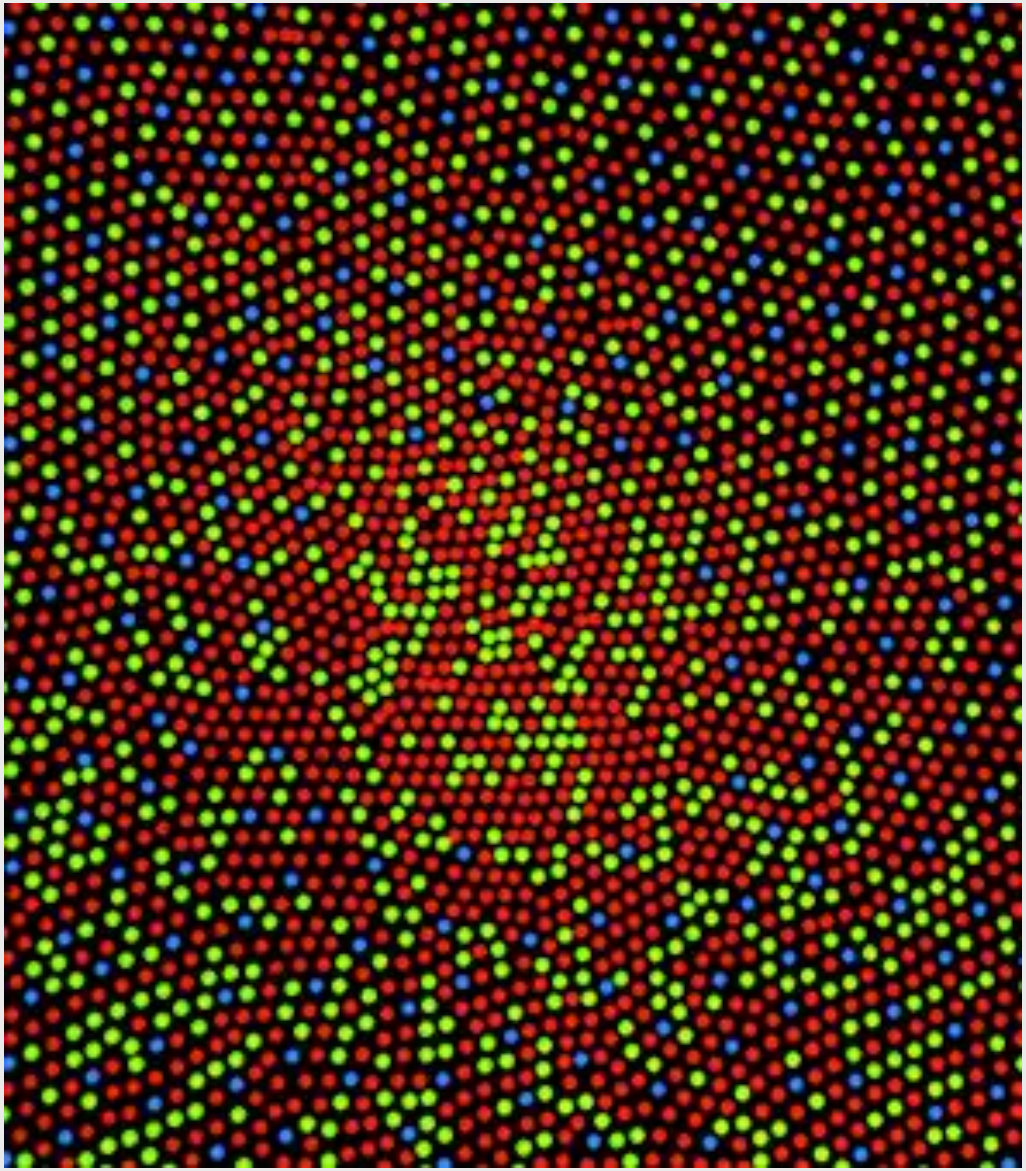


Digital technologies?

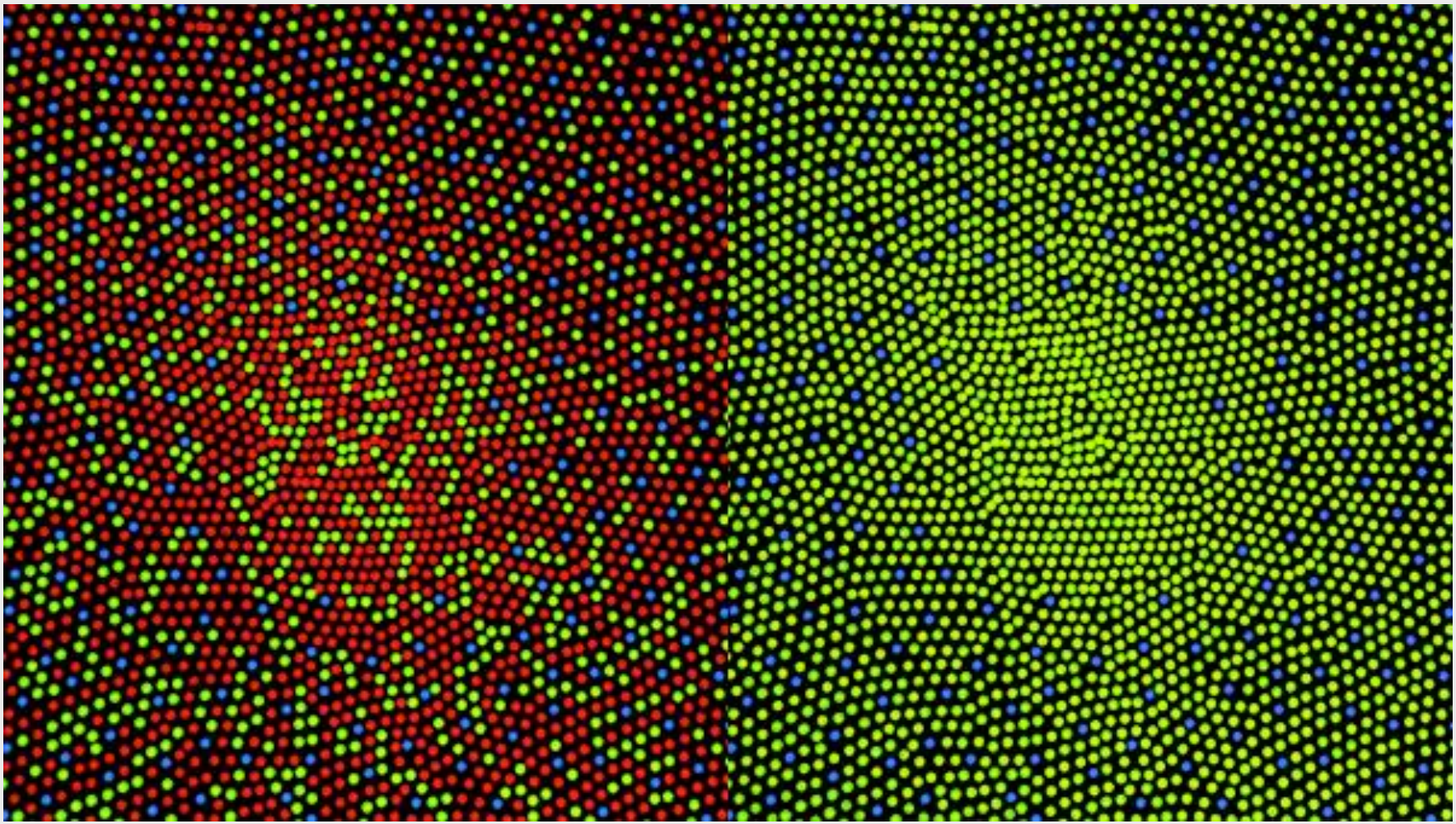


http://csfieldguide.org.nz/en/chapters/data-representation.html

Cone cells in the fovea



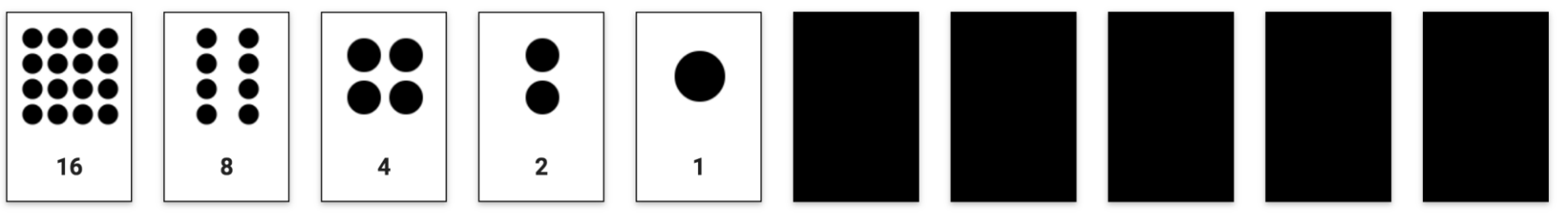
Cone cells in the fovea



Binary cards

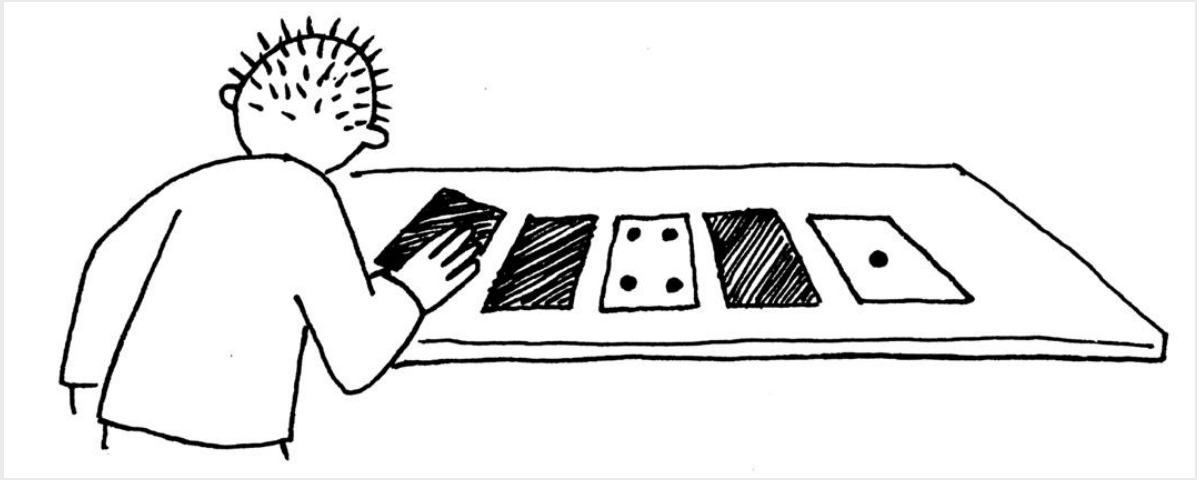
http://csfieldguide.org.nz/en/interactives/binary-cards/index.html?digits=5&start=BBBBB

Binary cards



http://csfieldguide.org.nz/en/interactives/binary-cards/index.html?digits=10&start=BBBBB&offset=-5

Binary cards

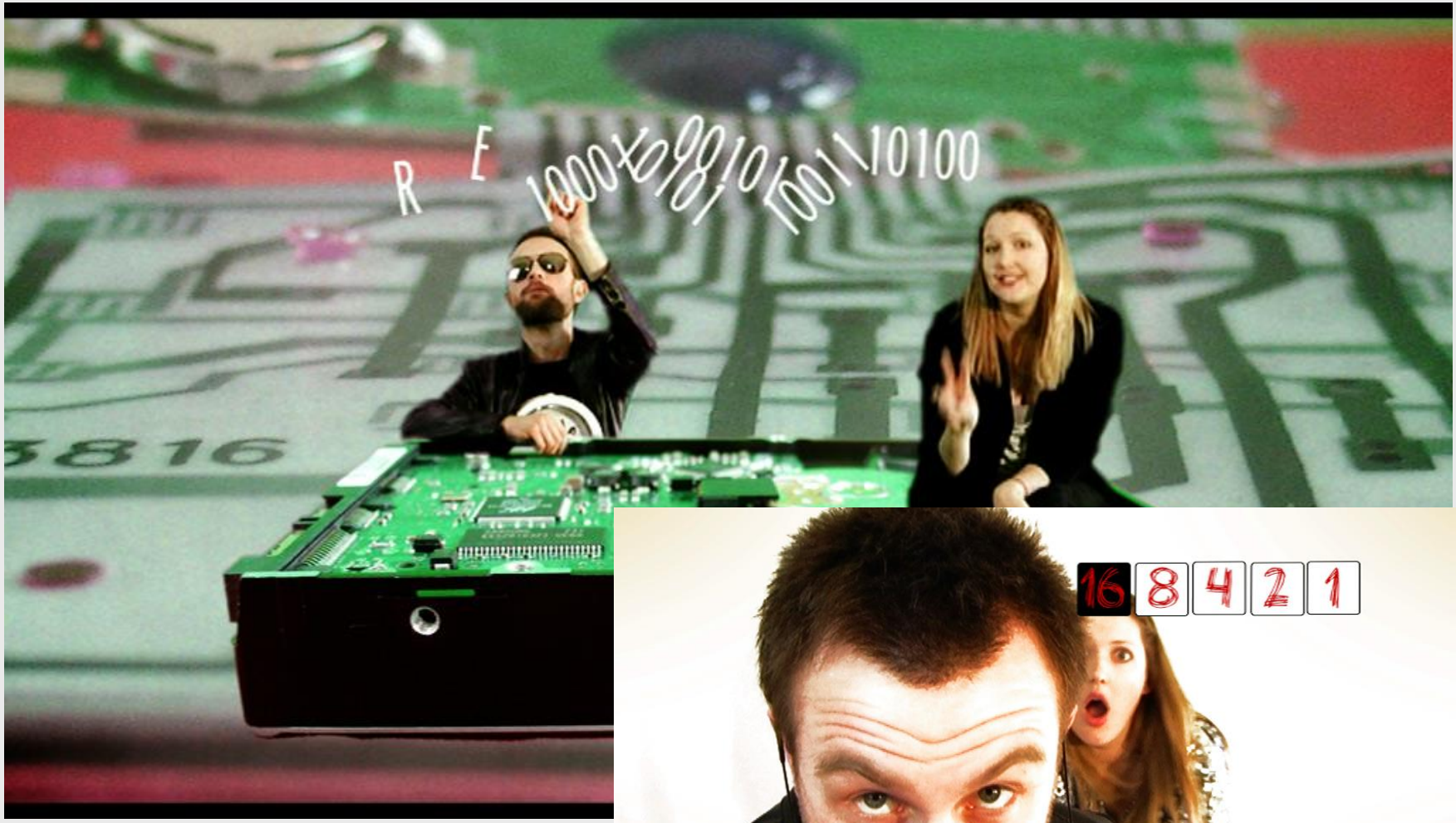


http://csunplugged.org/binary-numbers/

Letters using digits

0 – 00000 –	9 – 01001 – I	18 – 10010 – R
1 – 00001 – A	10 – 01010 – J	19 – 10011 – S
2 – 00010 – B	11 – 01011 – K	20 – 10100 – T
3 – 00011 – C	12 – 01100 – L	21 – 10101 – U
4 – 00100 – D	13 – 01101 – M	22 – 10110 – V
5 – 00101 – E	14 – 01110 – N	23 – 10111 – W
6 – 00110 – F	15 – 01111 – O	24 – 11000 – X
7 – 00111 – G	16 – 10000 – P	25 – 11001 – Y
8 – 01000 – H	17 – 10001 – Q	26 – 11010 – Z

Unplugged: Modem



http://csunplugged.org/modems-unplugged-2/

Algorithms interact with data

to solve computational problems

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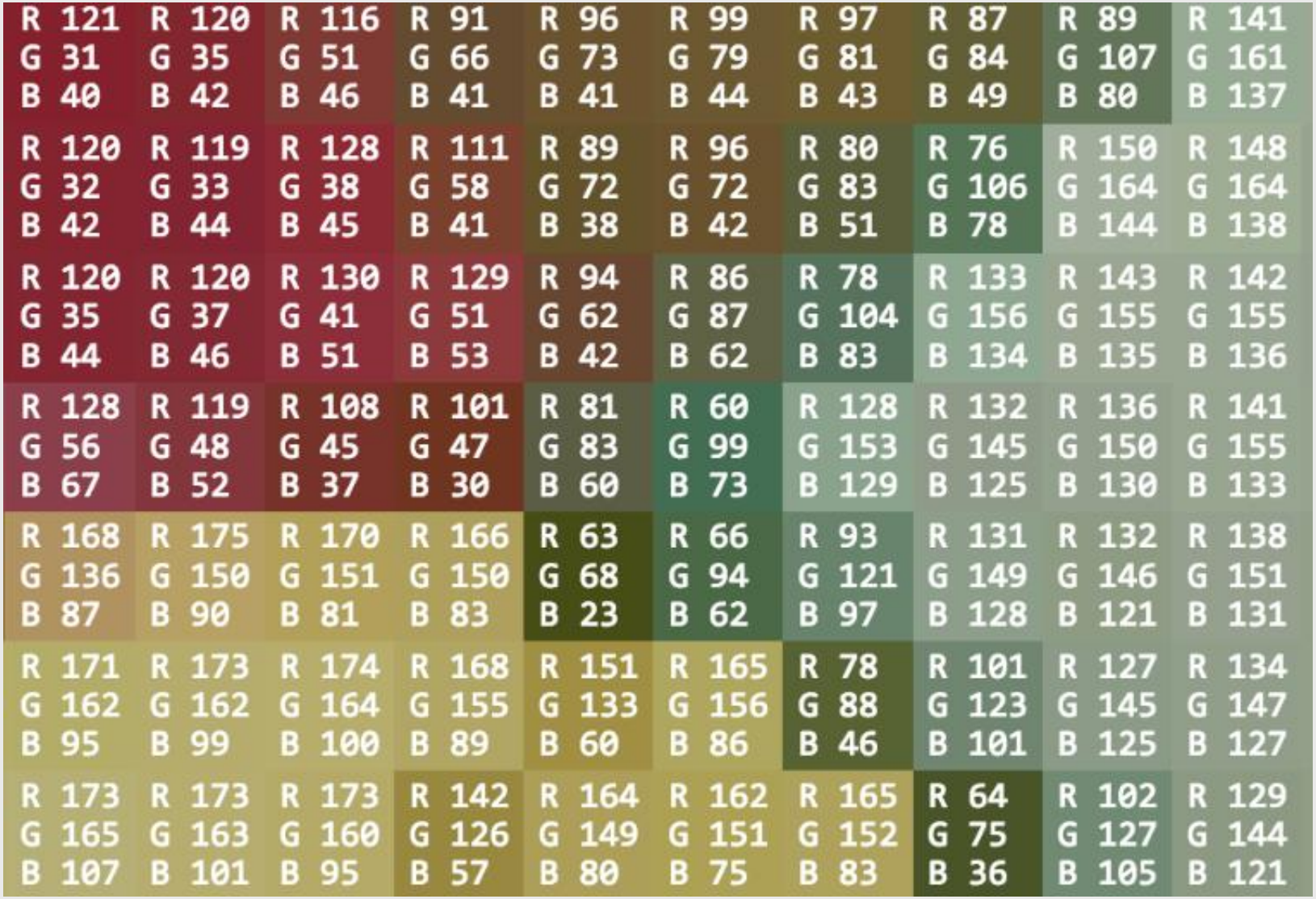
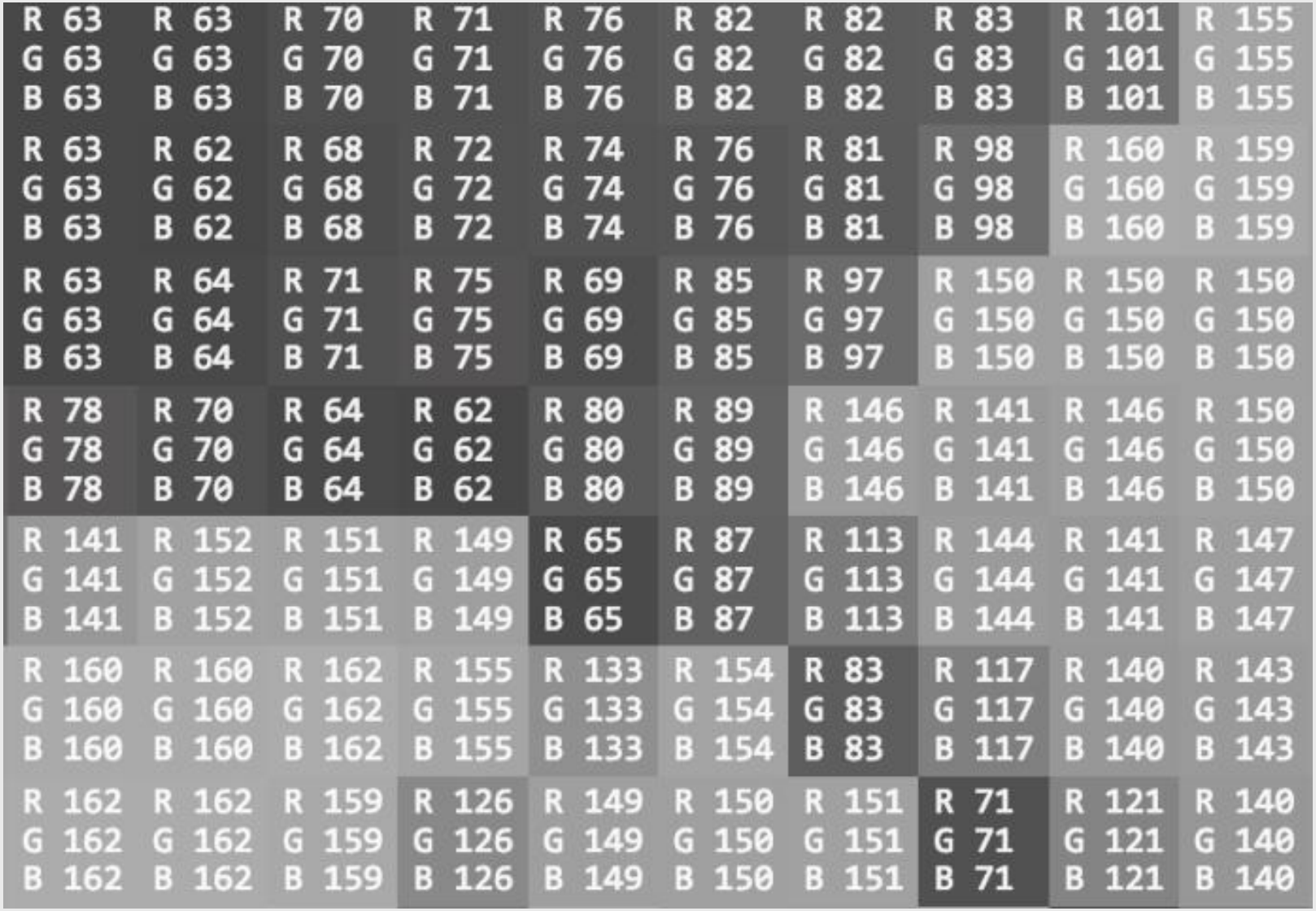
to solve computational problems



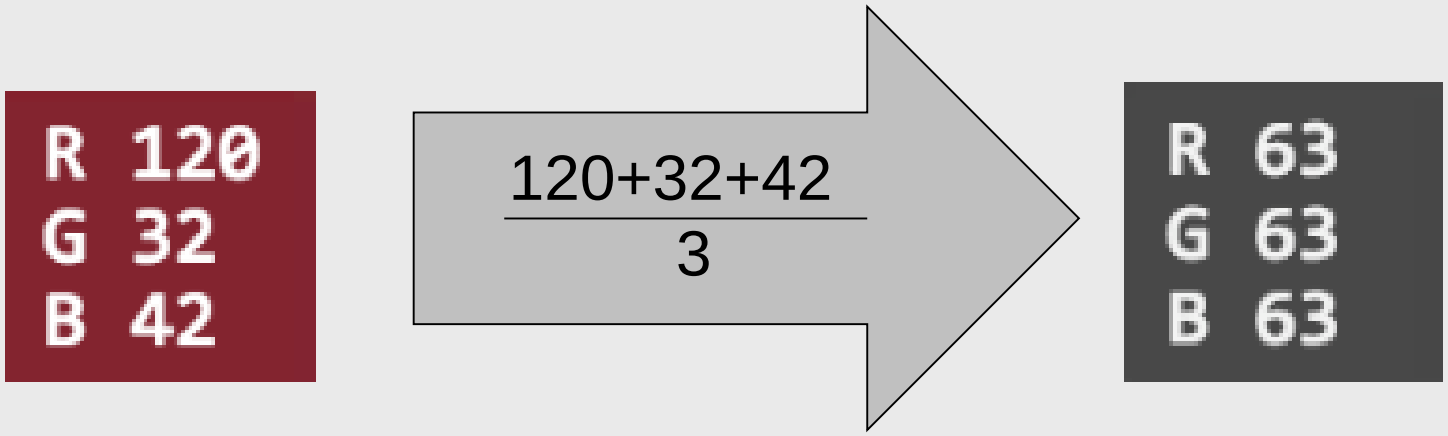
Algorithms interact with data

to solve computational problems



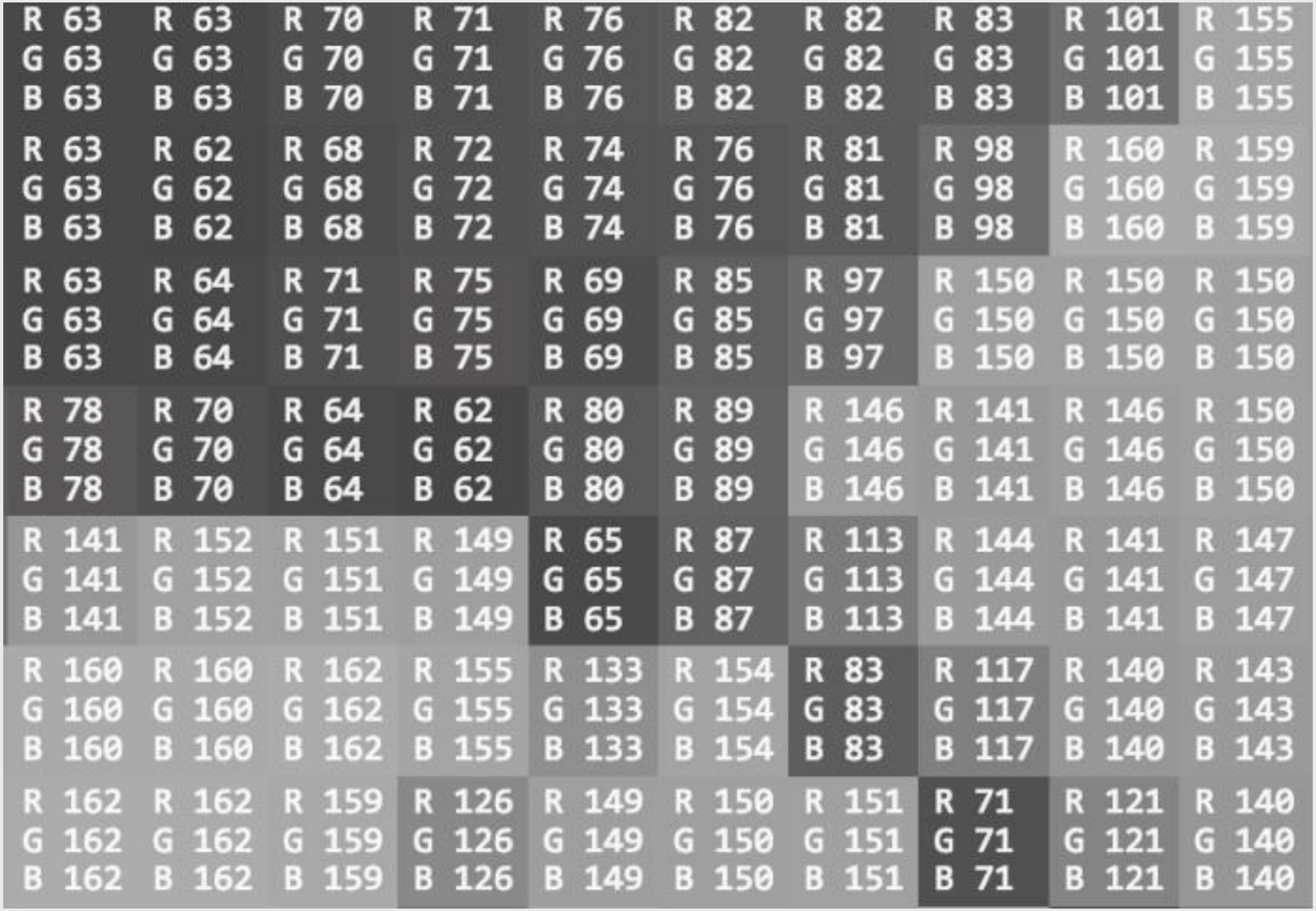
Algorithms interact with data

to solve computational problems



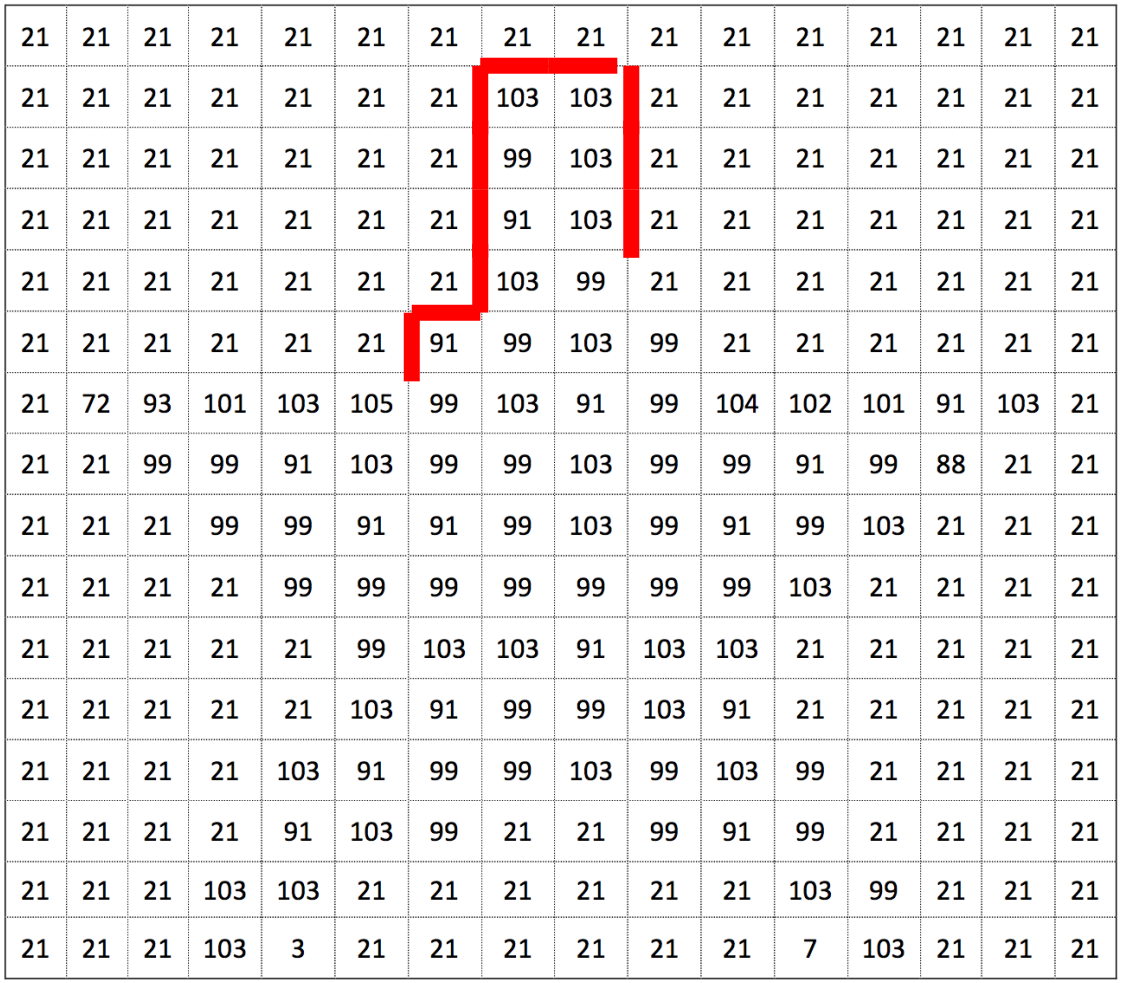

COMPUTER SCIENCE
WITHOUT A COMPUTER

Edge detection



Canny Unplugged

Try it yourself! The grid below is filled with numbers that represent a grayscale image. See if you can detect edges the way a computer would do it. **If the values of two neighboring squares on the grid differ by more than 50, draw a thick line between them.**



21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21
21	21	21	21	21	21	21	103	103	21	21	21	21	21	21	21
21	21	21	21	21	21	21	99	103	21	21	21	21	21	21	21
21	21	21	21	21	21	21	91	103	21	21	21	21	21	21	21
21	21	21	21	21	21	21	103	99	21	21	21	21	21	21	21
21	21	21	21	21	21	91	99	103	99	21	21	21	21	21	21
21	72	93	101	103	105	99	103	91	99	104	102	101	91	103	21
21	21	99	99	91	103	99	99	103	99	99	91	99	88	21	21
21	21	21	99	99	91	91	99	103	99	91	99	103	21	21	21
21	21	21	21	99	99	99	99	99	99	99	103	21	21	21	21
21	21	21	21	21	99	103	103	91	103	103	21	21	21	21	21
21	21	21	21	21	103	91	99	99	103	91	21	21	21	21	21
21	21	21	21	103	91	99	99	103	99	103	99	21	21	21	21
21	21	21	21	91	103	99	21	21	99	91	99	21	21	21	21
21	21	21	103	103	21	21	21	21	21	21	103	99	21	21	21
21	21	21	103	3	21	21	21	21	21	21	7	103	21	21	21

Algorithms interact with data

to solve computational problems

Add 1

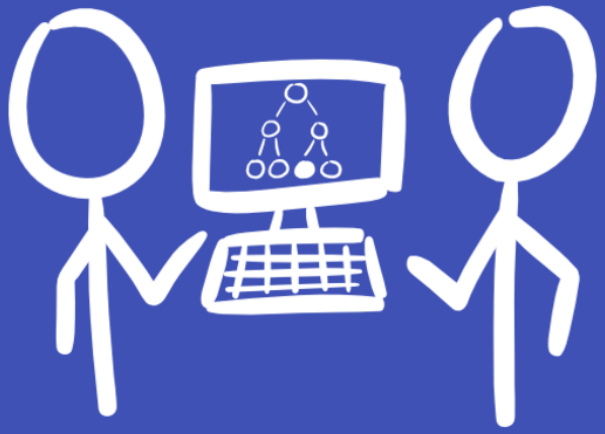
Example: Giving change

$75 change?

The performance of algorithr

can be modelled and evaluated

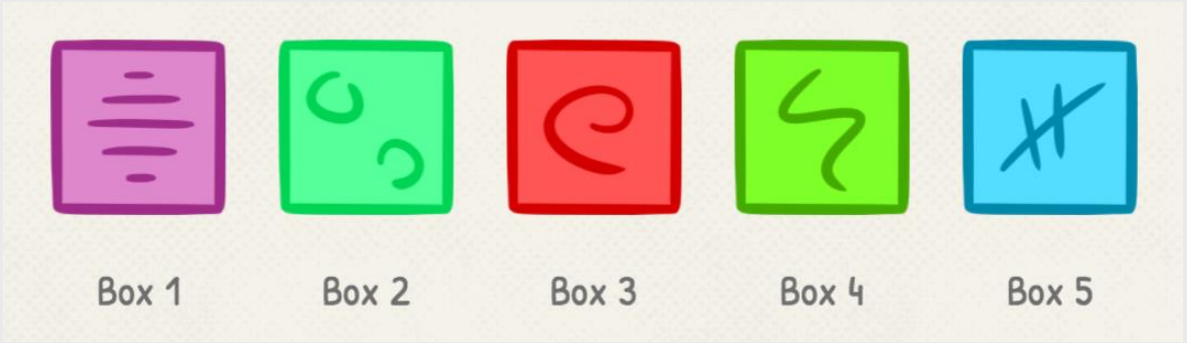
https://www.youtube.com/watch?v=iDVH3oCTc2c



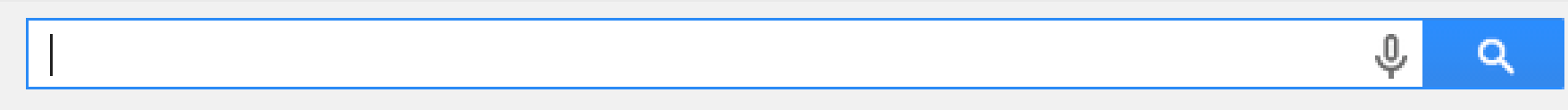
Computer Science Field Guide

- Algorithms
- Programming Languages
- Human Computer Interaction
- Data Representation
- Coding - Introduction
- Coding - Compression
- Coding - Encryption
- Coding - Error Control
- Artificial Intelligence
- Complexity and tractability
- Computer Graphics
- Computer Vision
- Formal Languages
- Network Communication Protocols
- Software Engineering

CSFG searching



Searching



Searching Phone Book

- **512 pages**

  256 pages,

  128 pages,

  64, 32, 16, 8, 4, 2, 1

  9 rips

- **1024 pages**

  512 pages,

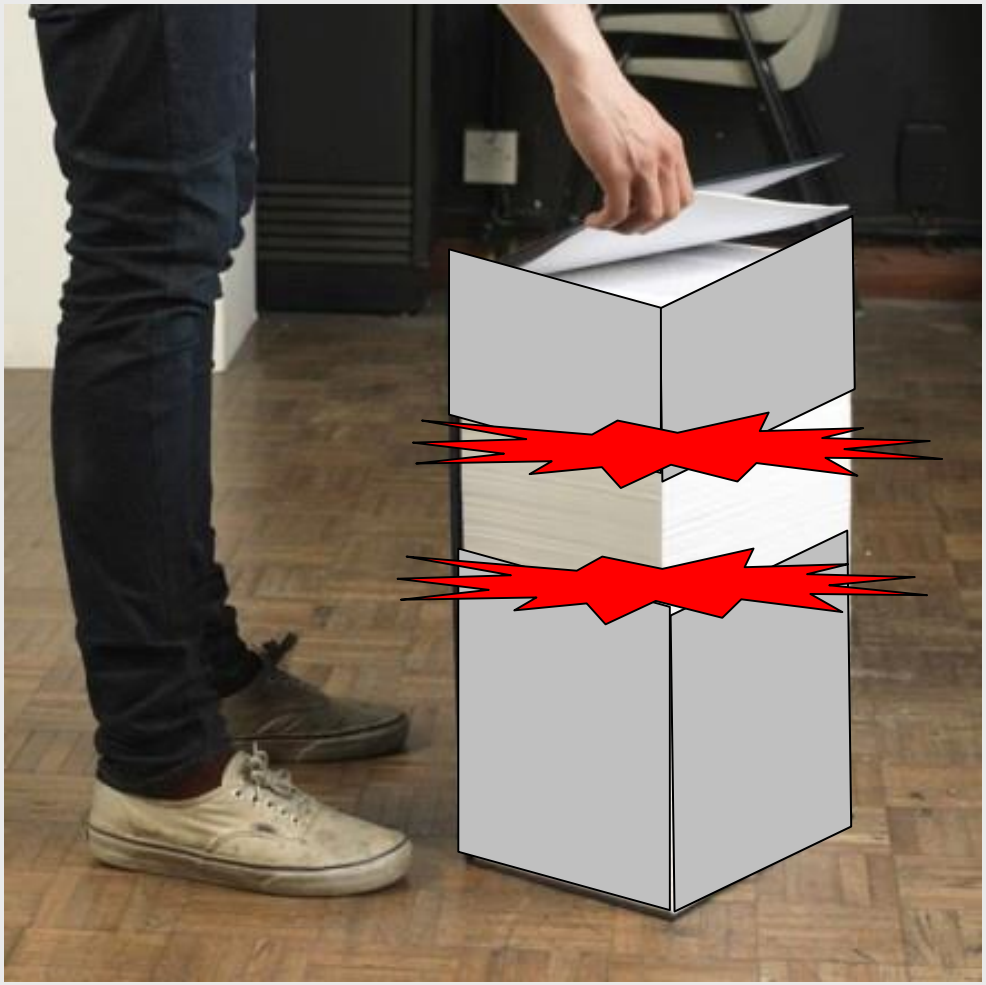
  256 pages,

  128, 64, 32, 16, 8, 4, 2, 1

  10 rips

5000 pages

- Wikipedia featured articles
- 2500 pages,
- 1250 pages,
- 625 pages …
- (13 rips)



Rob Matthews
http://www.geek.com/geek-cetera/0-01-of-wikipedia-turned-into-5000-page-book-1336419/

1,000,000 pages

- 500,000,
  250,000…
  … 1953,
  976
  (10 rips)

- 20 rips total

Pedia Press
http://hexus.net/business/news/internet/66305-wikipedia-encyclopaedia-become-million-page-book/

1,000,000,000 pages

50 km long

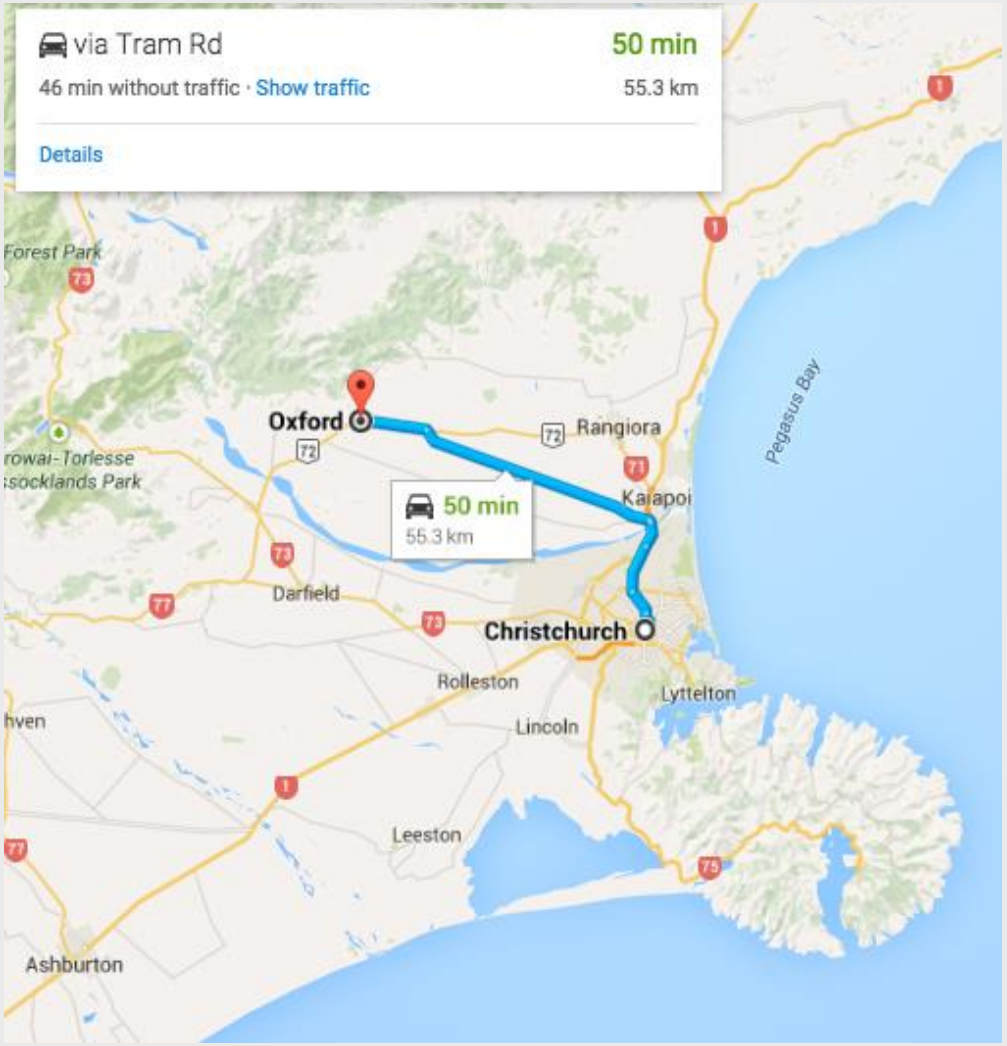
25km,

12.5km

6.25 km

Total?

30 rips

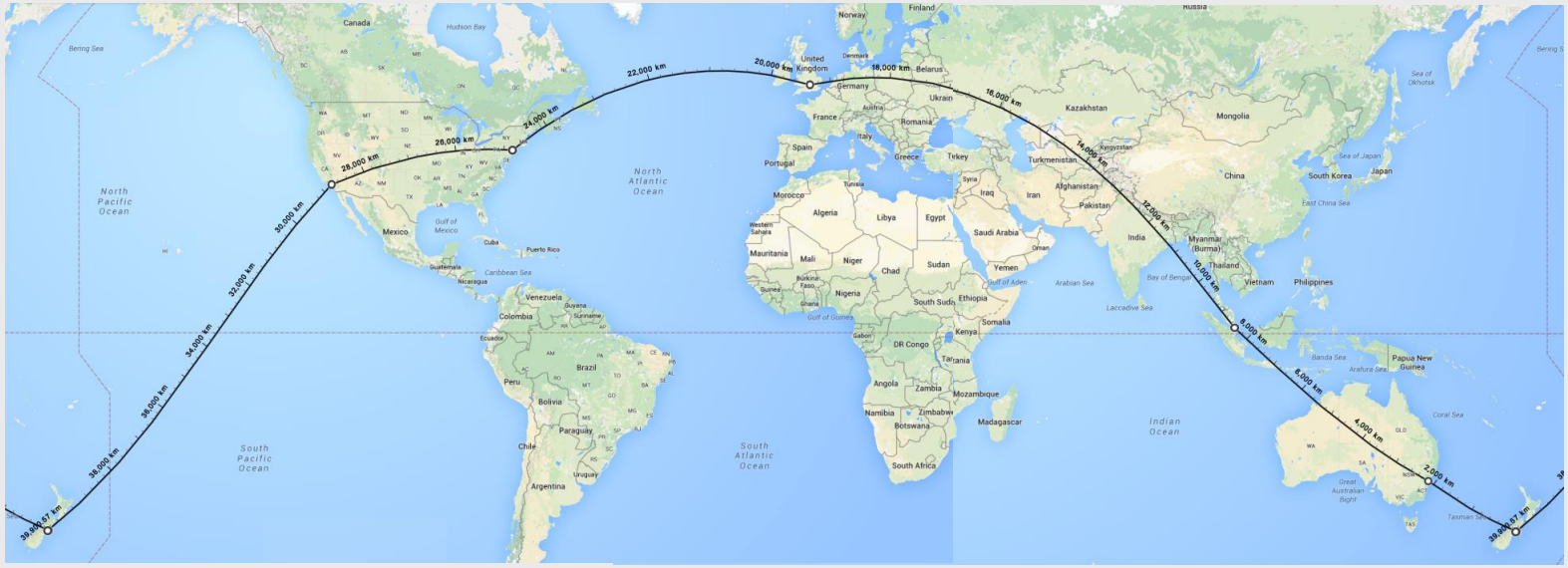


1,000,000,000,000 pages

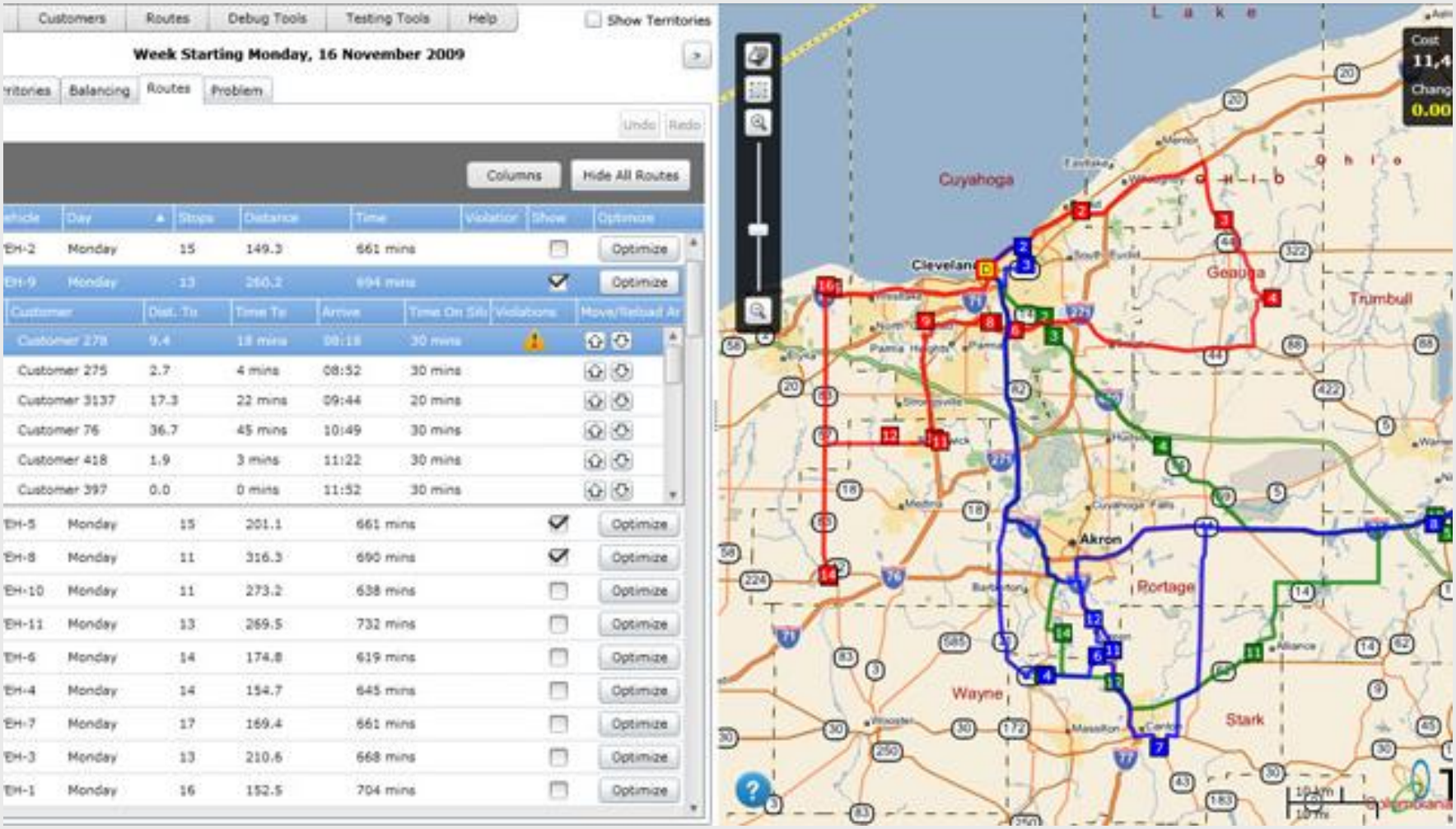
50,000 km long

Rips needed?

40 rips total



Telogis routing



Big ideas in CS

Some computational problems

cannot be solved by algorith

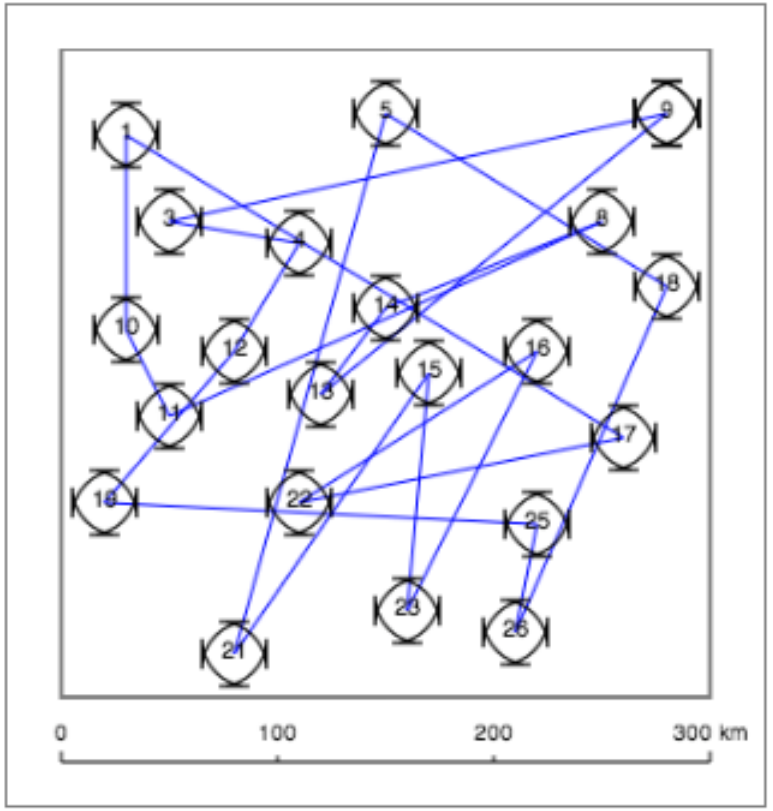
Generate Map | Start | Stop

Number of cities: 21

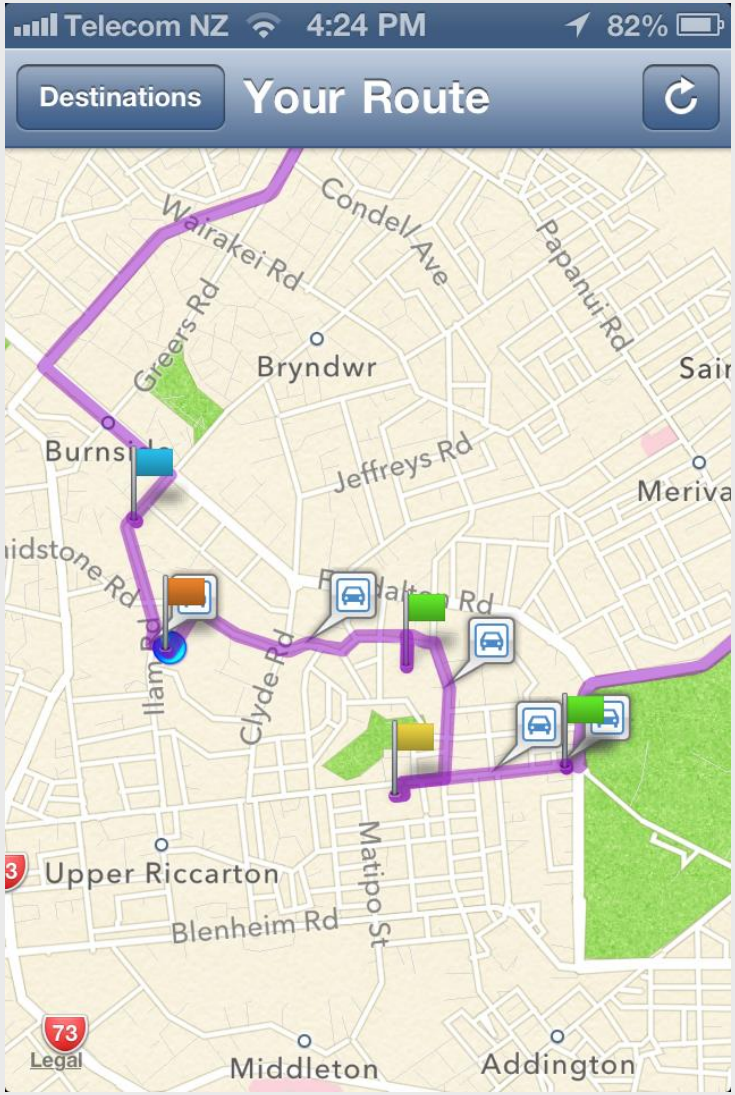
Estimated time left to run:
3,854,700,623 years
10 months
24 days
0 hours
0 minutes
0.00 seconds

Trial route: [13, 14, 8, 11, 10, 1, 17, 22, 16, 23, 15, 21, 5, 18, 26, 25, 19, 12, 4, 3, 9, 13]
Distance: 2949 km
Best so far: [13, 14, 8, 11, 10, 1, 17, 22, 16, 23, 15, 21, 5, 18, 26, 25, 19, 12, 4, 3, 9, 13]
Distance: 2949 km

Status: **Ready to go!**



Eco maps


Telecom NZ
4:24 PM
82%
Destinations
Your Route
Waitakei Rd
Condell Ave
Papanui Rd
Greers Rd
Bryndwr
Jeffreys Rd
Clyde Rd
Matipo St
Upper Riccarton
Blenheim Rd
Middleton
Addington
Legal

Hamina, Finland

Environmental impact

- **Speed of algorithm**
- **Structure of data**
- **Algorithms to optimise fuel consumption**

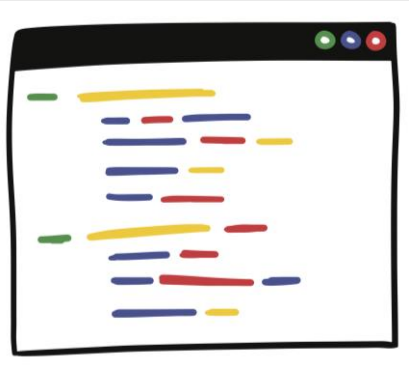
Some computational problems
cannot be solved by algorithms

Proof That Computers Can't Do Everything
(The Halting Problem)

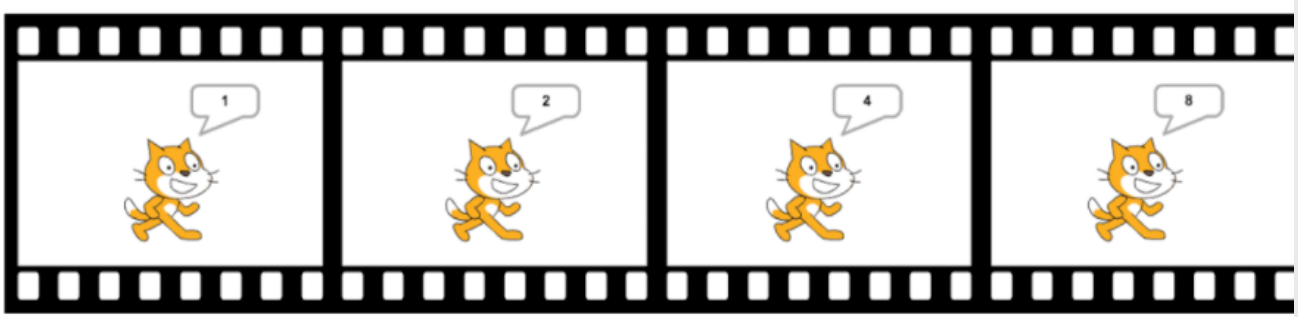
https://www.youtube.com/watch?v=92WHN-pAFCs

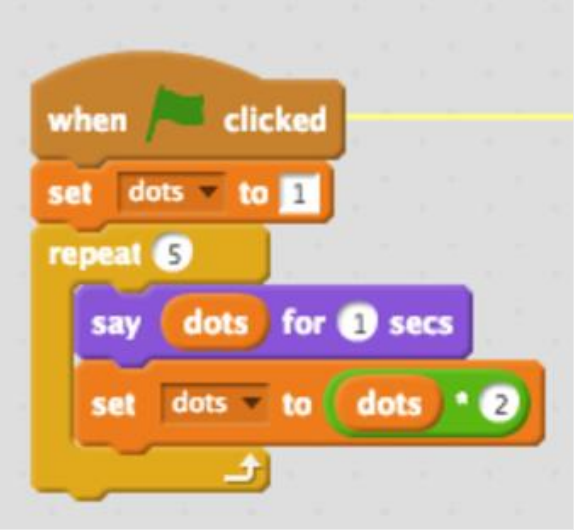
Programs express algorithms and data

in a form that can be implemented on a computer.



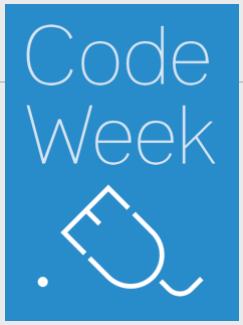
- Plugging it in



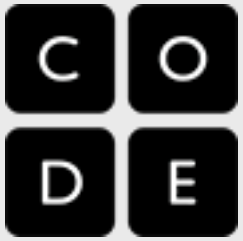


“Coding”


codecademy


Code
Week


CODE AVENGERS

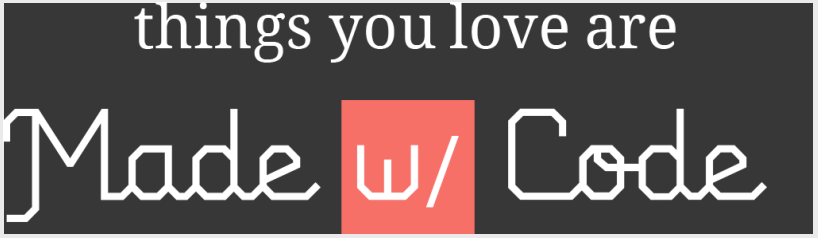

C O
D E


Hour of Code


{code
club}


YEAR
OF
CODE


[mothercoders]


things you love are
Made w/ Code


black girls CODE
imagine. build. create.

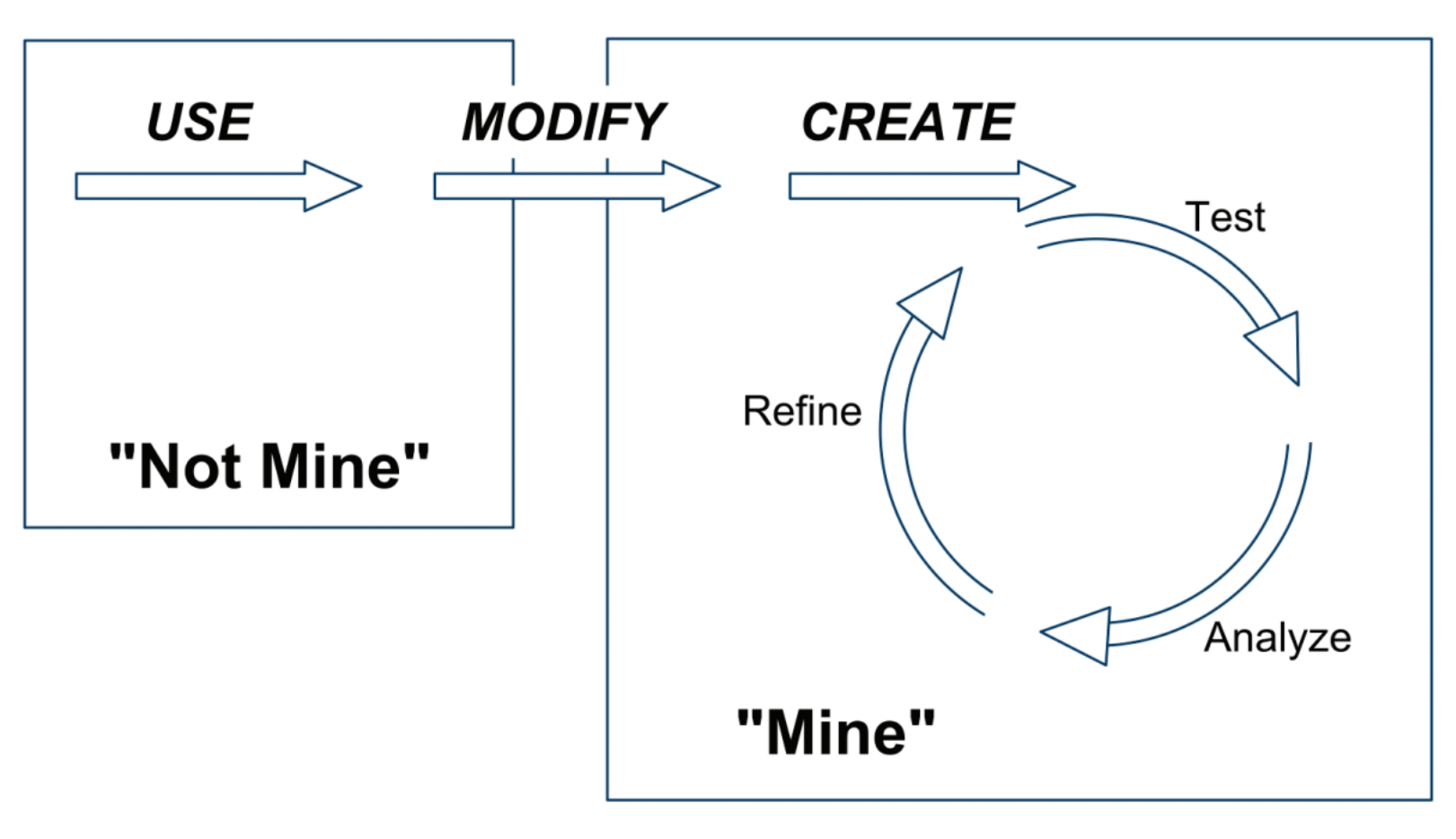

0
1
CoderDojo

Kidbots

Kidbots

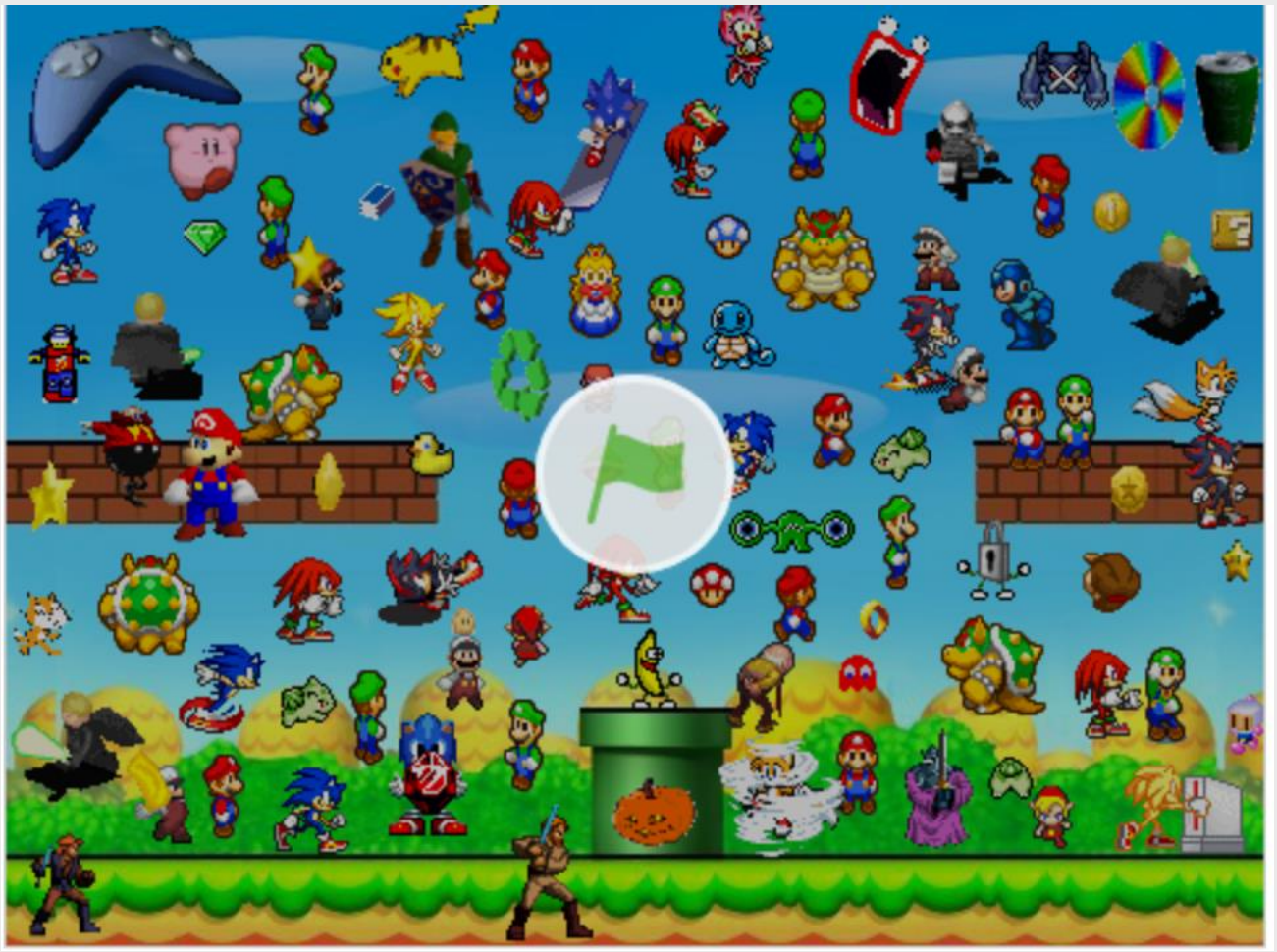
Kidbots

Kidbots



From Lee et al. ACM Inroads March 2011

Spritefest

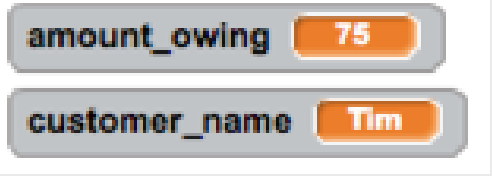


http://scratch.mit.edu/projects/3169725/

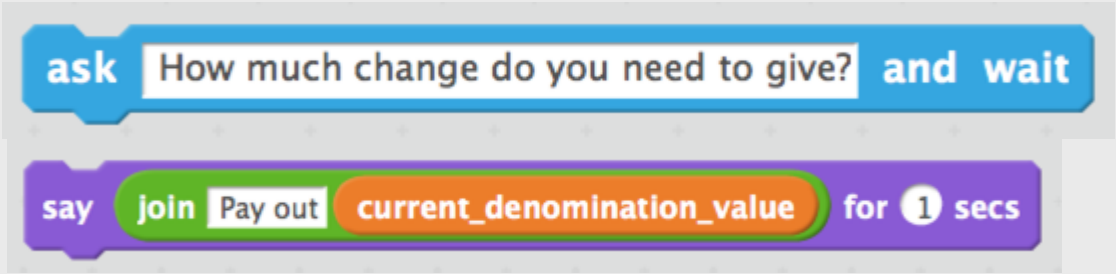
Programs express algorithms and data

in a form that can be implemented on a computer.

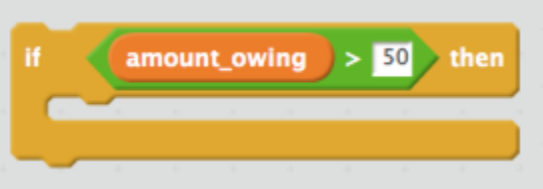
Storage

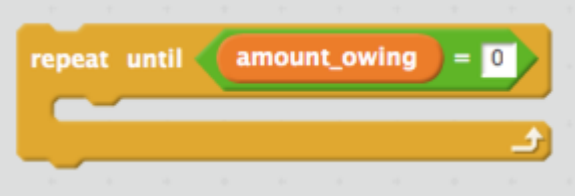


Input/output

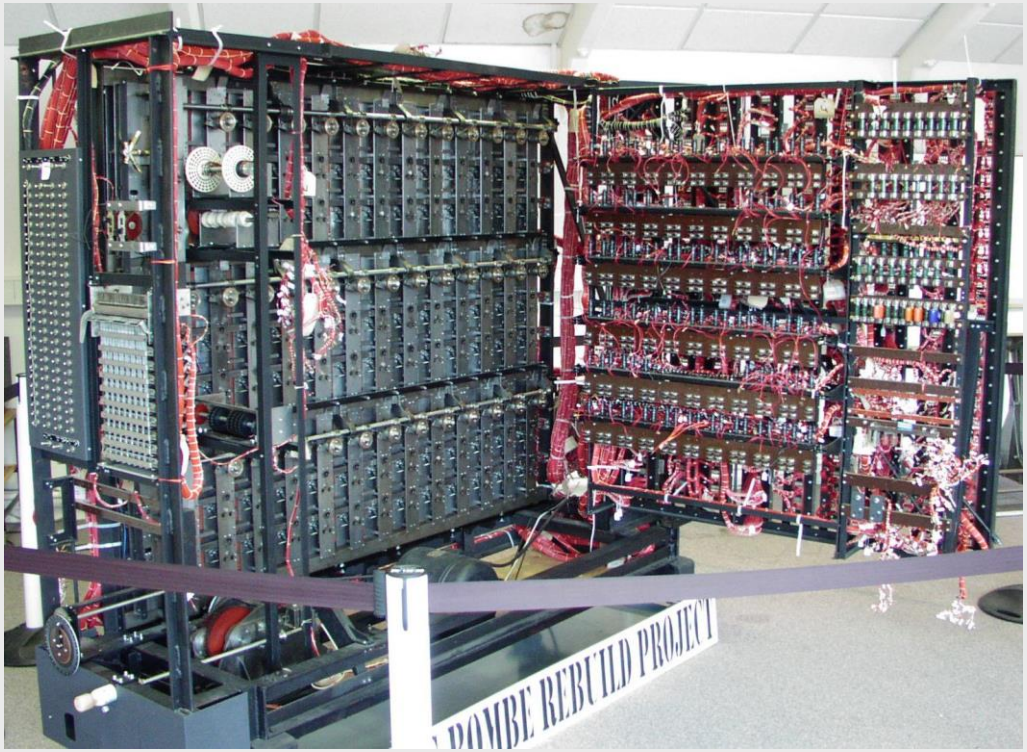


Sequence, selection, iteration

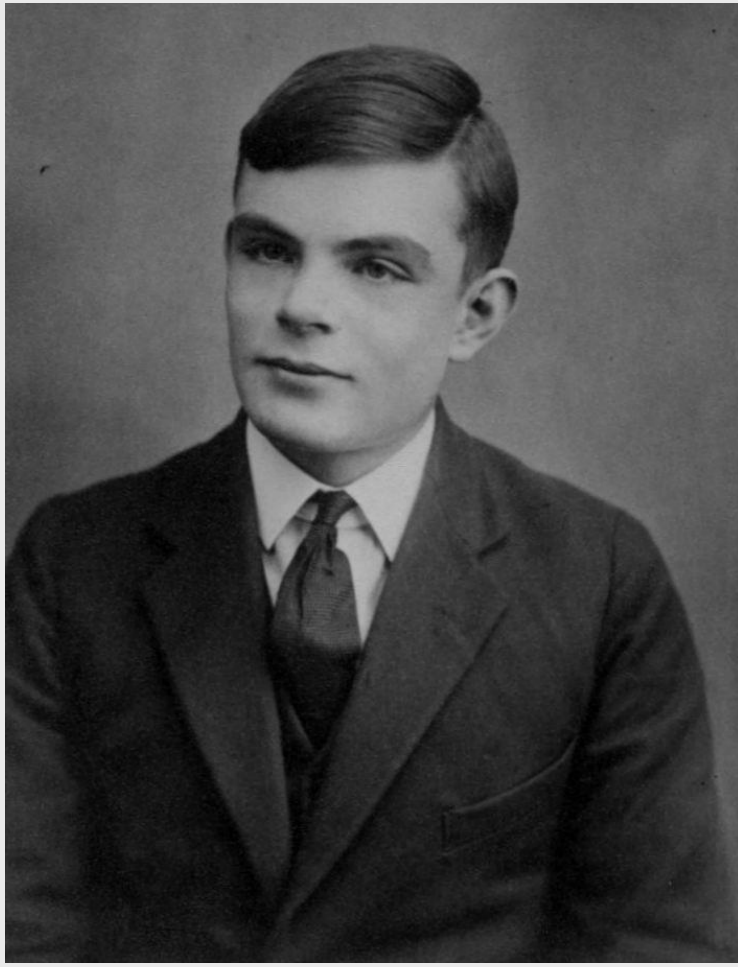




Turing-complete systems



https://commons.wikimedia.org/wiki/File:Bombe-rebuild.jpg



http://www.turingarchive.org/viewer/?id=521&title=4, Public Domain, https://commons.wikimedia.org/w/index.php?curid=22828488

Computer programs are written for…

the next programmer

Many skills of a professional programmer are related to social context rather than the technical one.

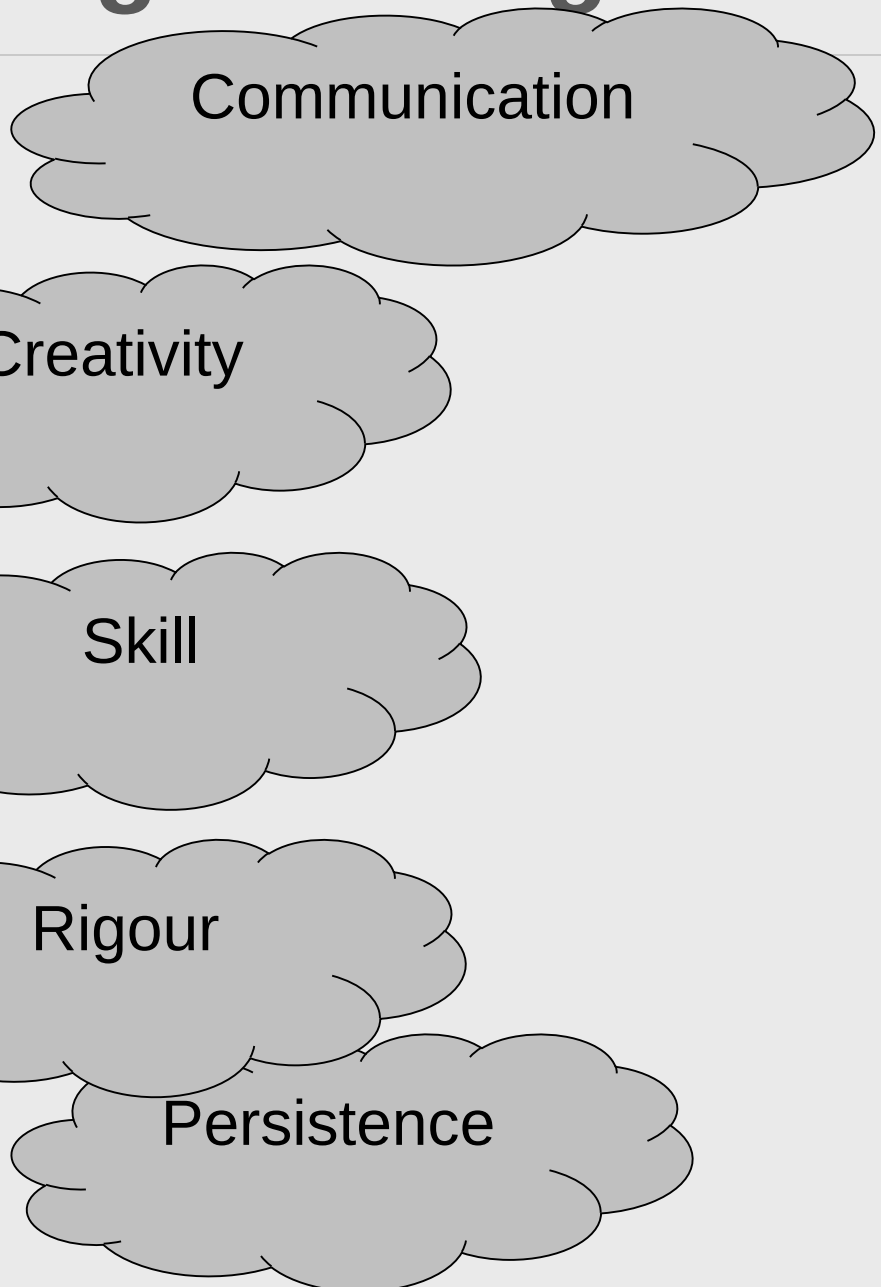
Blackwell, A. (2002). What is programming? In 14th workshop of the Psychology of Programming Interest Group (pp. 204-218).

```
def hs(s):
    xxy = s[0]
    for xxx in s:
        if xxx > xxy:
            xxy = xxx
    return xxy
```

```
def highest_score(scores):
    """takes a list of scores and returns the highest one"""
    highest_so_far = scores[0]
    for score in scores:
        if score > highest_so_far:
            highest_so_far = score
    return highest_so_far
```

Elements of programming

- **Analysis**
- **Design**
- **Coding**
- **Testing**
- **Debugging**

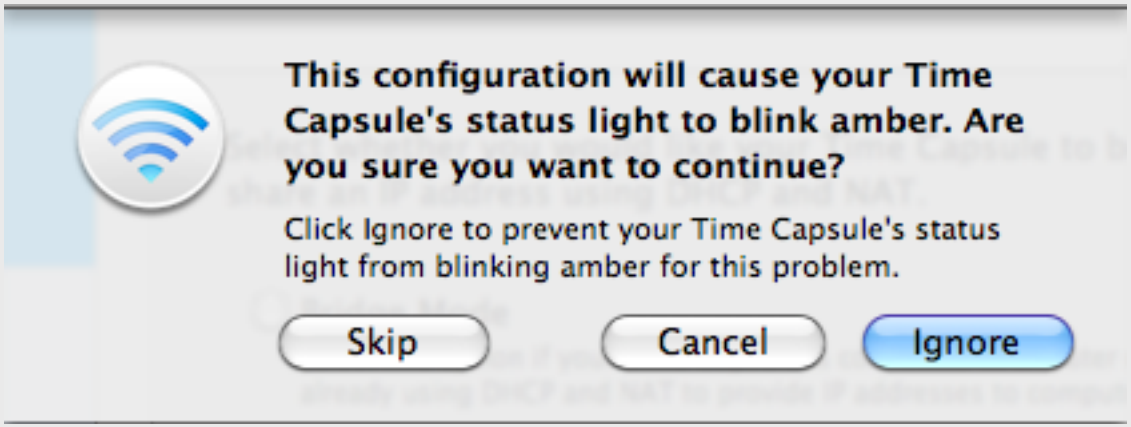


Choosing a language

- Good resources for teaching (online, books, peer support, software)
- Scaffolds from students' knowledge
- Encourages experimentation
- Motivates students
- Free

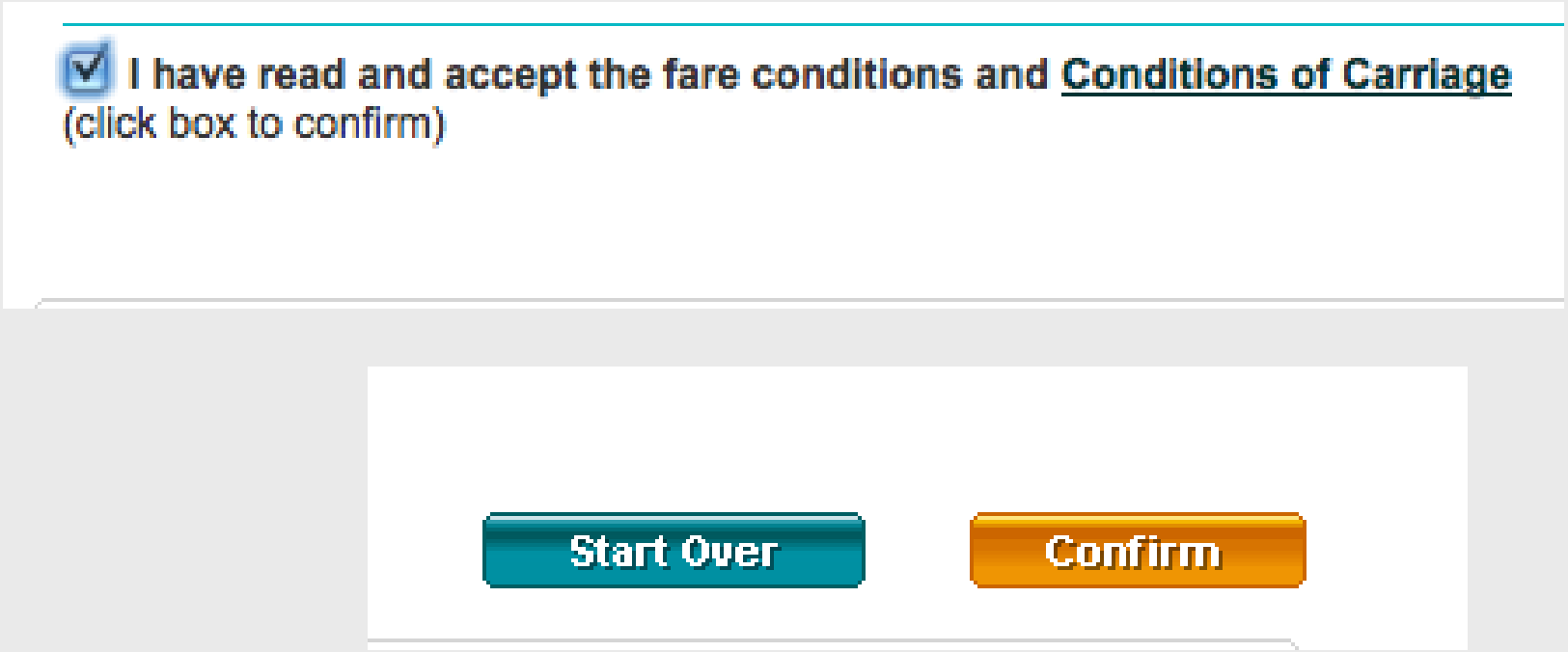
Computing systems are designed by

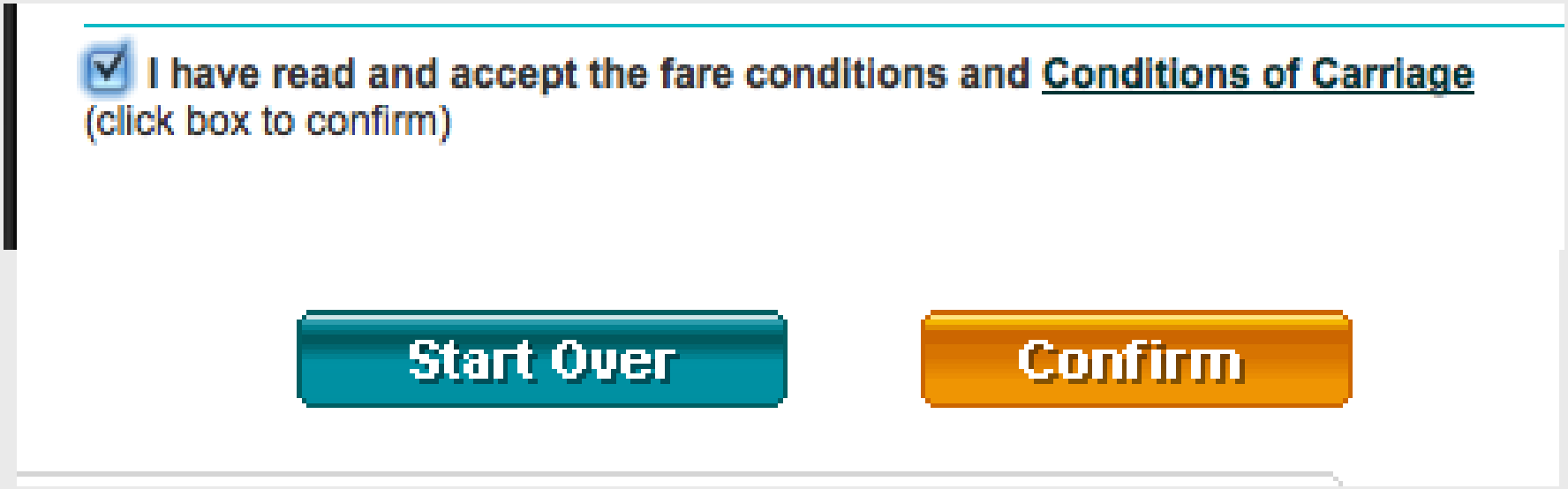
humans to serve human ne



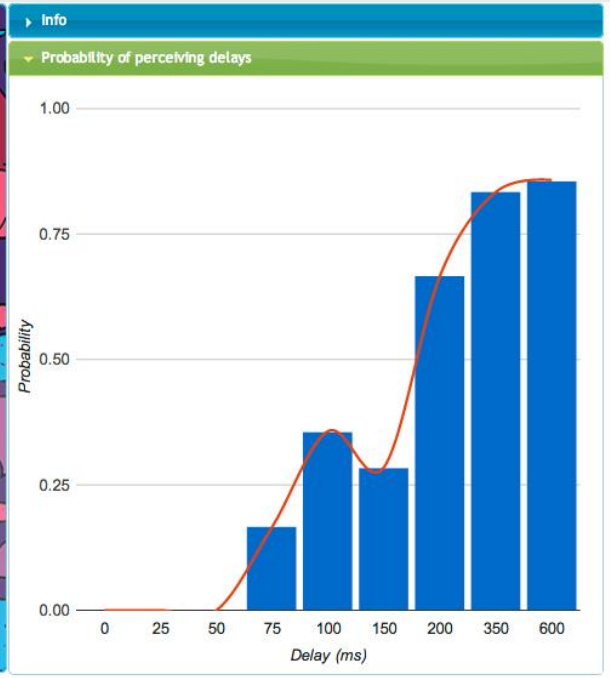
Programs are written for...

humans



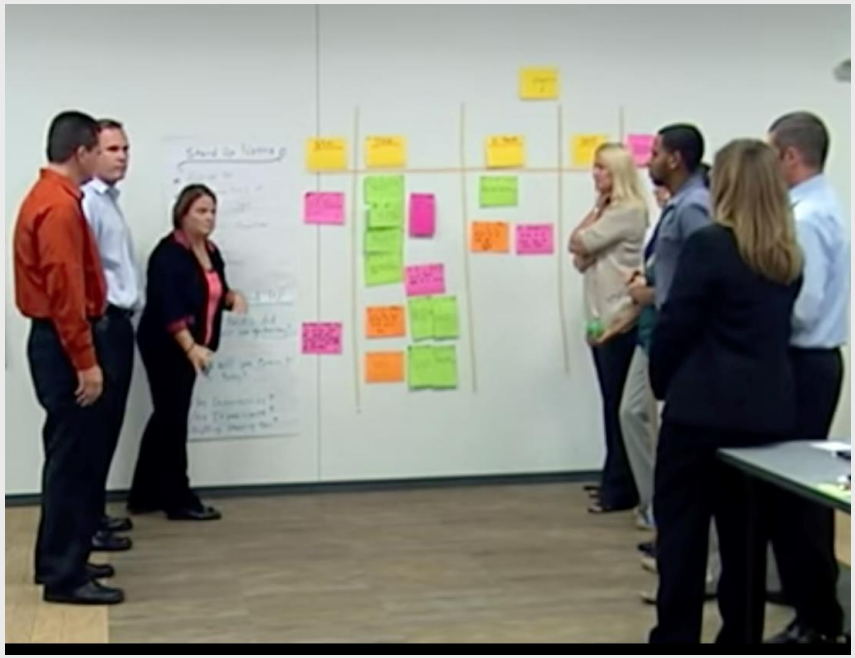

I have read and accept the fare conditions and Conditions of Carriage
(click box to confirm)
Start Over
Confirm

Reaction times?



Computing systems are designed by

humans to serve human needs



https://www.youtube.com/watch?v=q_R9wQY4G5I

Diversity – broadening participation

http://techblog.nz/689-TheITGirls

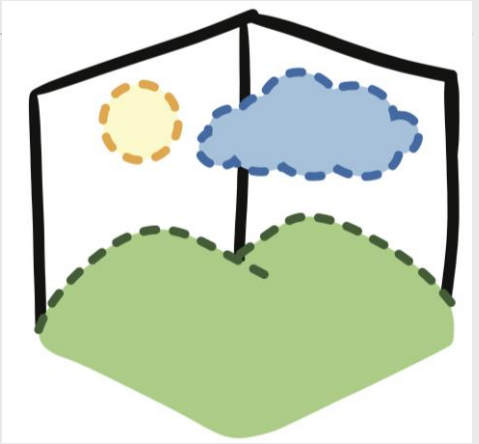
http://au.tv.yahoo.com/sunrise/video/watch/21339850/blind-genius-building-apps-for-google/

A better motivation…

"The greatest tragedy I know of is that so many young people **never discover what they really want to do.**"

Edna Kerr
(quoted by Dale Carnegie)

Computing systems create virtual representations of natural and artificial phenomena



https://www.kiwinet.org.nz/images/success-stories/AugmentedReality.jpg

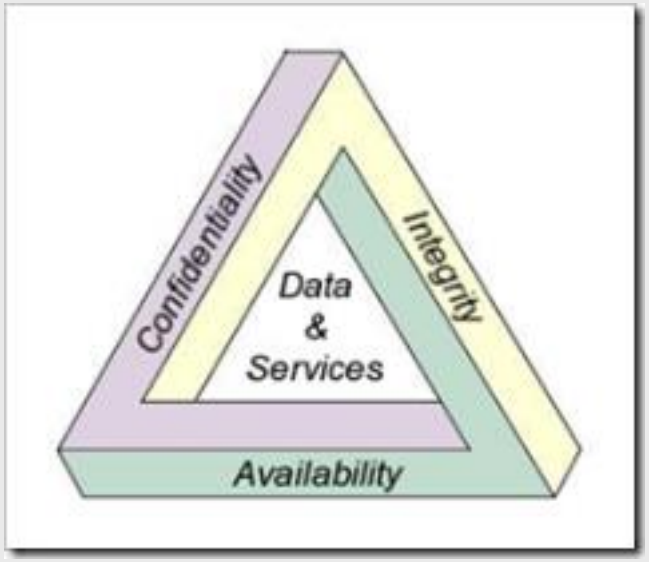
Models include...

- Simulations
- Spreadsheets
- Graphics
- AI
- Virtual machines
- Virtual/augmented reality

Protecting data and system resources

is critical in computing systems.

- Examples:
  - PKS
  - Hashed password
  - Coin toss

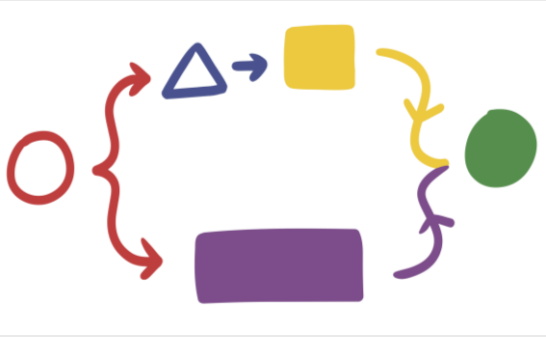


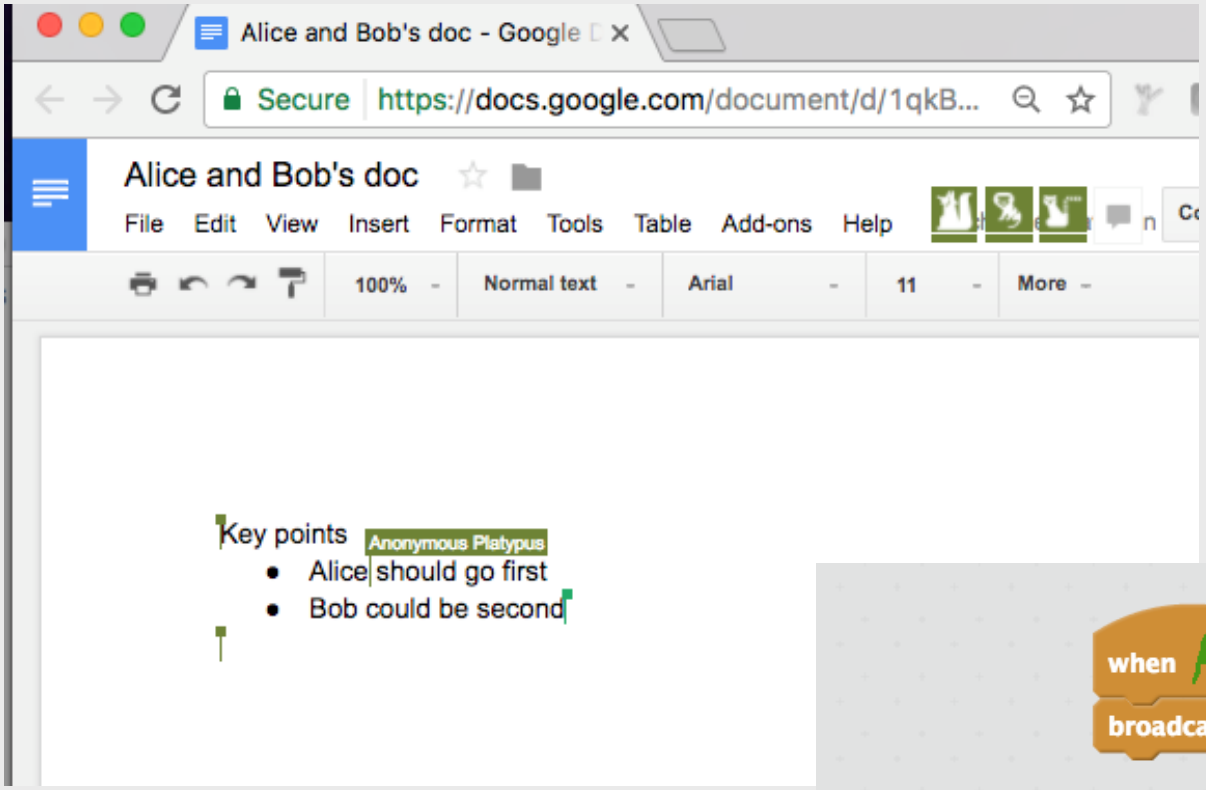
https://blogs.technet.microsoft.com/seanearp/2007/08/01/layers-defense-in-depth-part-1/

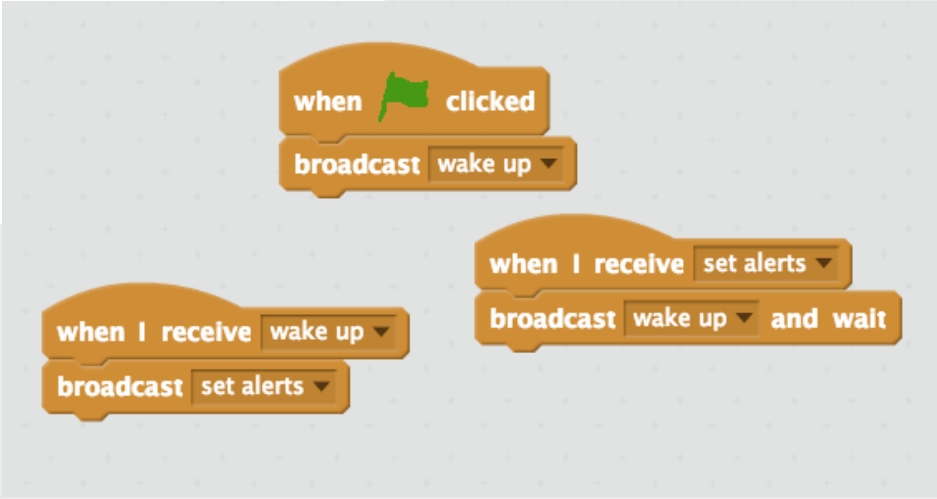
Lockbox demo - PKS

Time dependent operatio

in computing systems must be coordinated







Parallel sorting network

Integrated learning

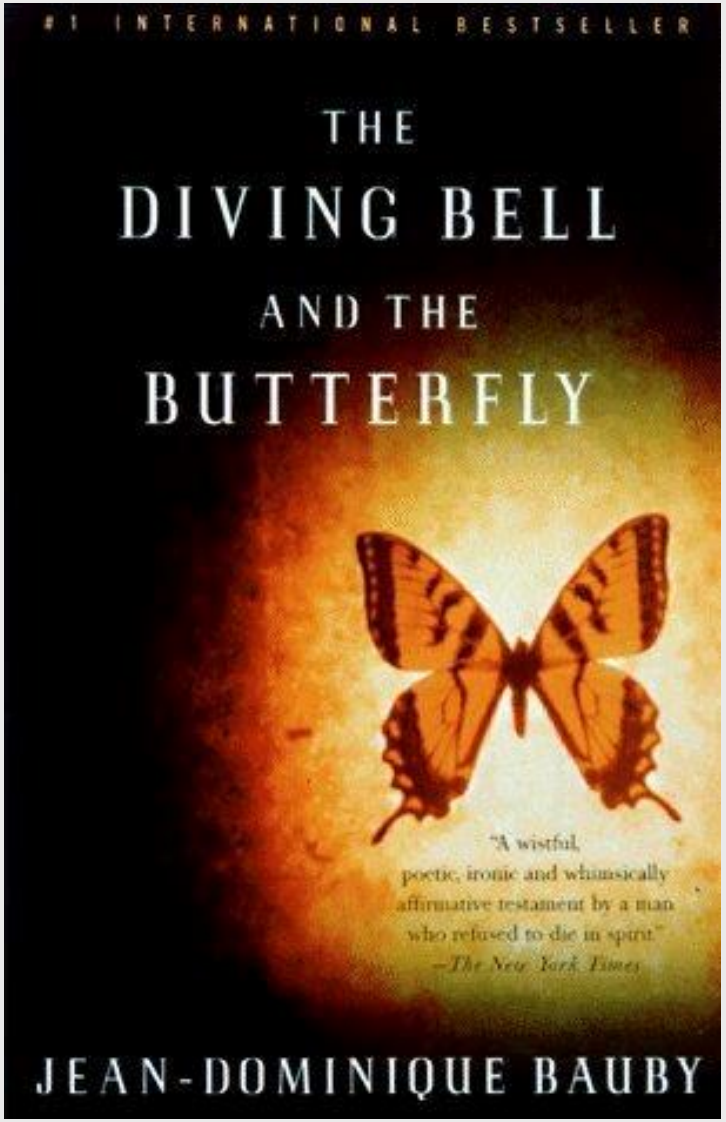
http://chisnallwoodmusic.org.nz/wp/wp-content/uploads/2016/06/2016-06-17-16.16.27.mp4

Protocols facilitate communication

between computing systems

Name	Meth…	Status	Type	Initiator	Size	Time	Waterfall
www.google.com	GET	302	text/…	Other	433B	50ms	
?gfe_rd=cr&ei=Sv62WNGgNtLr8AeJoKjoCA	GET	200	docu…	https://www…	38.2KB	263ms	
gsa_super_g-64.gif	GET	200	gif	?gfe_rd=cr…	21.8KB	325ms	
googlelogo_color_160x56dp.png	GET	200	png	?gfe_rd=cr…	7.0KB	181ms	
rs=AA2YrTu-pFGahmg0_r6skyDfpReXWdGLng	GET	200	script	?gfe_rd=cr…	20.9KB	50ms	
qi2_00ed8ca1.png	GET	200	png	?gfe_rd=cr…	3.3KB	48ms	
photo.jpg	GET	200	jpeg	?gfe_rd=cr…	(from disk c…	2ms	
data:image/png;base…	GET	200	png	?gfe_rd=cr…	(from mem…	0ms	
rs=ACT90oHm4z_AKMMfL6ZOBxtr6b2gaZSwyw	GET	200	script	?gfe_rd=cr…	128KB	74ms	
rs=ACT90oHm4z_AKMMfL6ZOBxtr6b2gaZSwyw	GET	200	script	rs=ACT90o…	22.6KB	52ms	
search?client=mobile-gws-hp&hl=en-NZ&gs_rn=…	GET	200	xhr	rs=ACT90o…	443B	219ms	
nav_logo242.png	GET	200	png	Other	(from disk c…	2ms	
gen_204?s=mobilewebhp&atyp=csi&ei=S_62WK…	GET	204	text/…	Other	23B	193ms	
rs=AA2YrTvvYlgFmYK0OmsJFhJXcUYROuDYVA	GET	200	style…	?gfe_rd=cr…	2.7KB	55ms	
gen_204?atyp=i&ct=14&cad=i&ogsr=1&id=19001…	GET	204	text/…	Other	23B	185ms	
count	POST	200	xhr	rs=AA2YrTu…	570B	539ms	
gen_204?atyp=i&ct=14&cad=v&ogsr=1&id=1900…	GET	204	text/…	Other	46B	185ms	

Locked-in syndrome



https://teachinglondoncomputing.org/resources/inspiring-unplugged-classroom-activities/the-locked-in-activity/

The big ideas

1. **Data** is represented in digital form on a computer.
2. **Algorithms** interact with data to solve computational problems.
3. The **performance** of algorithms can be modelled and evaluated.
4. Some computational problems **cannot be solved** by algorithms.
5. **Programs** express algorithms and data in a form that can be implemented on a computer.
6. Computing systems are designed by **humans** to serve human needs.
7. Computing systems create **virtual** representations of natural and artificial phenomena.
8. **Protecting** data and system resources is critical in computing systems.
9. **Time dependent** operations in computing systems must be coordinated.
10. **Protocols** facilitate communication between computing systems.

Digital technologies is about… people

- Communication
- Information
- Interfaces
- Privacy
- Safety
- Solving real problems
- Careers

www.orionhealth.com

www.youtube.com/watch?v=cdgQpa1pUUE

He aha te mea nui ki tēnei ao? Māku e ki atu. He tangata, he tangata, he tangata.

Computer Science without a computer

CS Unplugged is a collection of free teaching material that teaches Computer Science through engaging games and puzzles that use cards, string, crayons and lots of running around.

Welcome to the new CS Unplugged!

This updated website has unit plans, lesson plans, teaching videos, curriculum integration activities, and programming exercises to plug in the Computer Science concepts they have just learnt unplugged.

The original activities are still available at classic.csunplugged.org.

What is Computer Science?

How do I teach CS Unplugged?

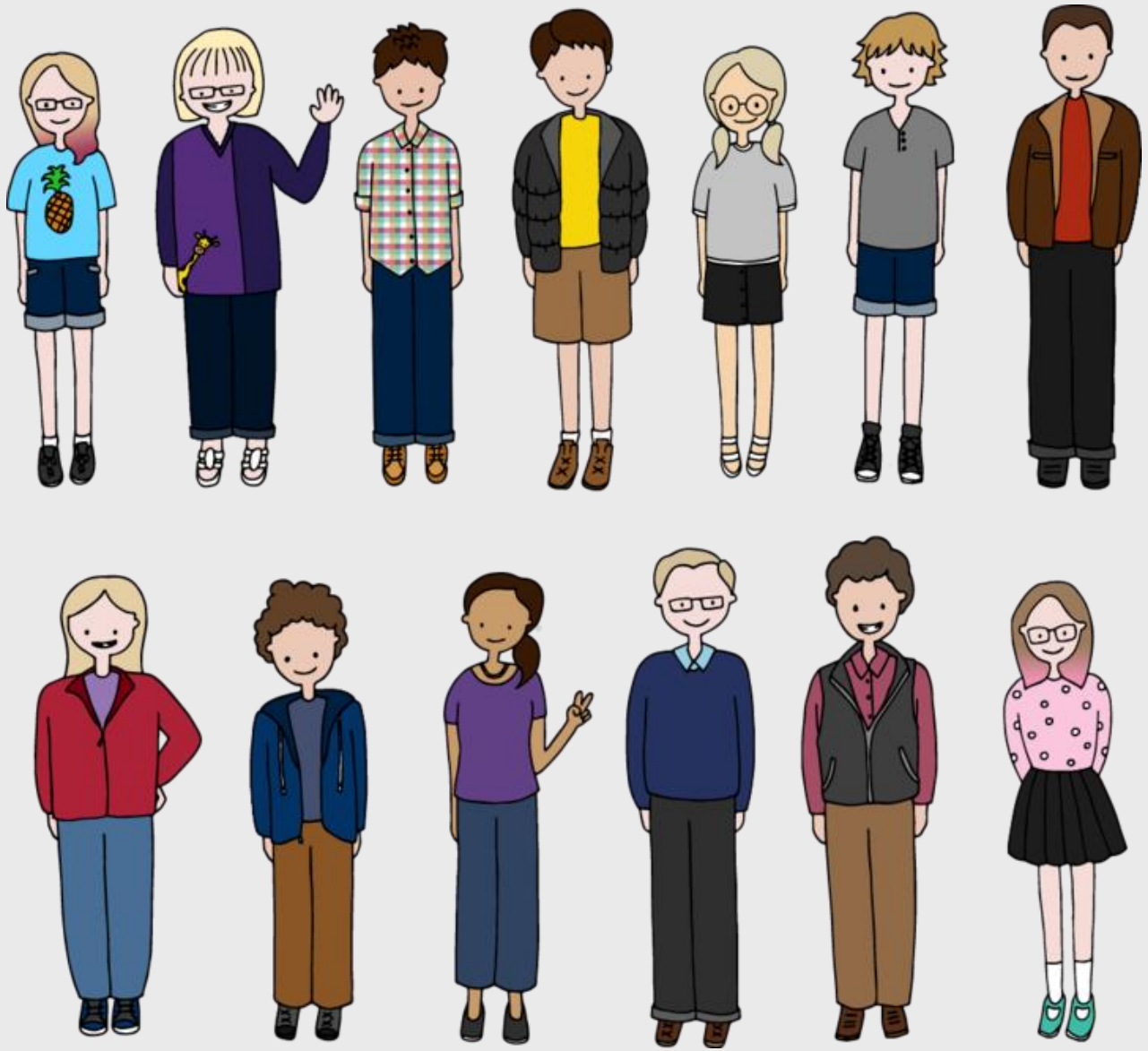
Topics

Printables

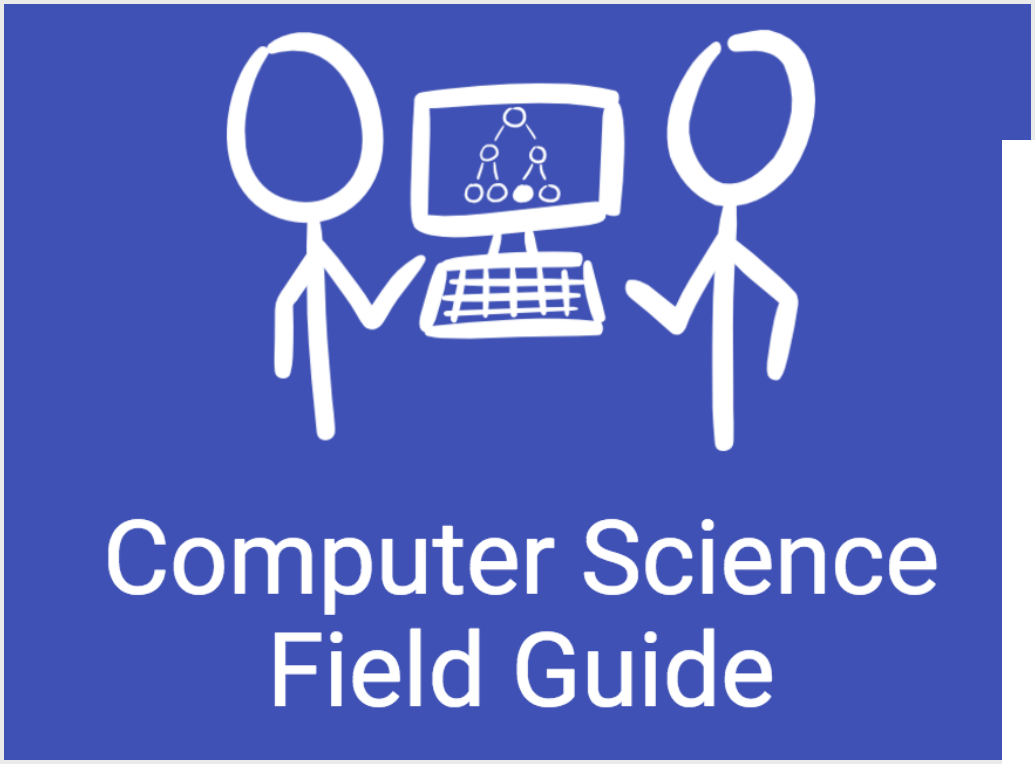
Curriculum Integrations

Classic CS Unplugged

Department of Fun Stuff



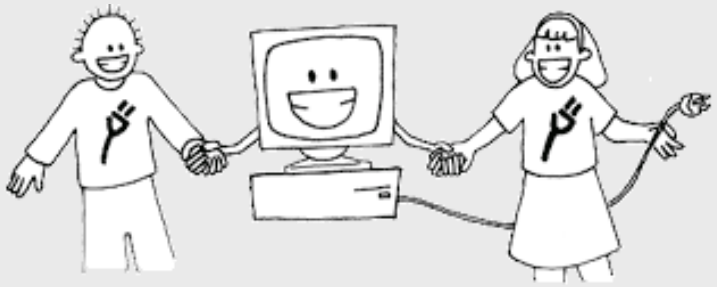
csfieldguide.org.nz



- Algorithms
- Programming Languages
- Human Computer Interaction
- Data Representation
- Coding - Introduction
- Coding - Compression
- Coding - Encryption
- Coding - Error Control
- Artificial Intelligence
- Complexity and tractability
- Computer Graphics
- Computer Vision
- Formal Languages
- Network Communication Protocols
- Software Engineering

Big ideas in CS

http://www.cosc.canterbury.ac.nz/research/RG/CSE/big-ideas/



tim.bell@canterbury.ac.nz