UC Berkeley EECS
Adj. Ass. Prof.
Dr. Gerald Friedland

Computational Structures in Data Science

Lecture #2: Algorithmic Structures

EVERYONE SECRETLY STORES DATA (EVEN IF THEY DON'T ADMIT TO IT)

https://www.wired.com/2016/09/heres-happens-two-designers-speak-infographics/

September 2, 2016 http://inst.eecs.berkeley.edu/~cs88

Requirements for CS61b and CS Major

c8	CS88	CS47a	CS61b	CS major
c8	CS88	CS61b		CS non-major

- **Data8+CS88 qualify you for CS61b**
- **CS majors: Need to take CS47a any time *after* CS88 to fulfill requirements.**

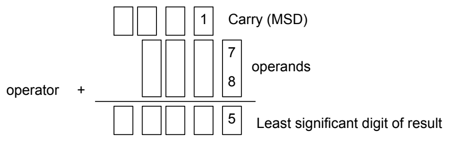
Computational Concepts today

- **Algorithm, Code, Data, Information**
- **Data Types, Simple Data Structures**
- **Function Definition Statement**
- **Conditional Statement**
- **Iteration**

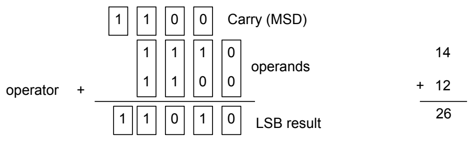
Algorithm

- **An algorithm (pronounced AL-go-rith-um) is a procedure or formula for solving a problem.**
- **In mathematics and computer science, an algorithm is a self-contained step-by-step set of operations to be performed.**
- **An algorithm is an effective method that can be expressed within a finite amount of space and time and in a well-defined formal language for calculating a function.**

Algorithms early in life



Algorithms early in life (in binary)



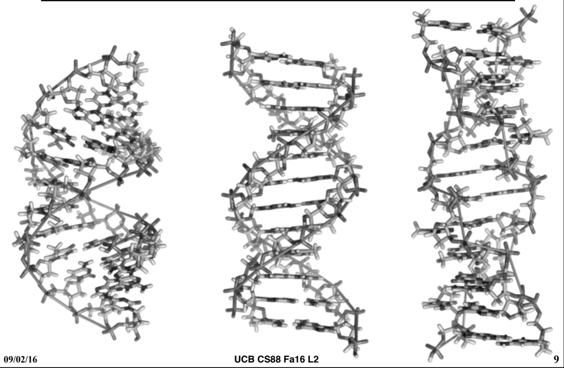
More Terminology (Dictionary)

- **Code**
  A system of symbols (as letters or numbers) of communication
- **Data**
  Facts and statistics collected together for reference or analysis
- **Information**
  Facts provided or learned about something or someone

Experiment

Algorithm vs Code vs Data vs Information

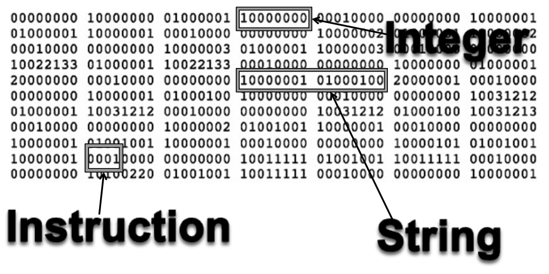
Data or Code?



Data or Code?

```
00000000 10000000 01000001 10000000 00010000 00000000 10000001
01000001 10000001 00010000 00000000 10000002 01000001 10000002
00010000 00000000 10000003 01000001 10000003 00010000 00000000
10022133 01000001 10022133 00010000 00000000 10000000 01000001
20000000 00010000 00000000 10000001 01000100 20000001 00010000
00000000 10000001 01000100 10000000 00010000 00000000 10031212
01000001 10031212 00010000 00000000 10031212 01000100 10031213
00010000 00000000 10000002 01001001 10000001 00010000 00000000
10000001 01001001 10000001 00010000 00000000 10000101 01001001
10000001 00010000 00000000 10011111 01001001 10011111 00010000
00000000 10100220 01001001 10011111 00010000 00000000 10000001
```

Data or Code?



```
00000000 10000000 01000001 10000000 00010000 00000000 10000001
01000001 10000001 00010000 00000000 10000002 [illegible] [illegible]
00010000 00000000 10000003 01000001 10000003 [illegible] [illegible]
10022133 01000001 10022133 00010000 00000000 10000000 01000001
20000000 00010000 00000000 10000001 01000100 20000001 00010000
00000000 10000001 01000100 10000000 00010000 00000000 10031212
01000001 10031212 00010000 00000000 10031212 01000100 10031213
00010000 00000000 10000002 01001001 10000001 00010000 00000000
10000001 01001001 10000001 00010000 00000000 10000101 01001001
10000001 00010000 00000000 10011111 01001001 10011111 00010000
00000000 10100220 01001001 10011111 00010000 00000000 10000001
```

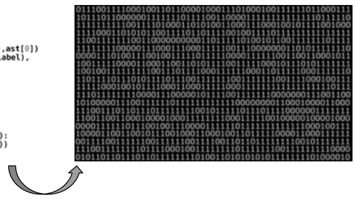
Data or Code?

Human-readable code (programming language)

Machine-executable instructions (byte code)

```
def add5(x):
    return x+5

def dotwrite(ast):
    nodename = getNodename()
    label=symbol.sym_name.get(int(ast[0]),ast[0])
    print ' %s [label="%s' % (nodename, label),
    if isinstance(ast[1], str):
        if ast[1].strip():
            print '= %s"];' % ast[1]
        else:
            print '"]'
    else:
        print '"];'
        children = []
        for n, child in enumerate(ast[1:]):
            children.append(dotwrite(child))
        print ' %s -> {' % nodename,
        for name in children:
            print '%s' % name,
```



Compiler or Interpreter
Here: Python

Language Structures (Python)

- **Variables** and **literals**
  - **with some internal representation, e.g. Integers, Floats, Booleans, Strings, …**

  In Python: Implicit data types!
- **Operations** on variable and literals of a **type**
  - **e.g.** `+, *, -, /, %, //, **`
  - `==, <, >, <=, >=`
- **Expressions** are valid well-defined sets of operations on variables and literals that produce a value of a type.
  - `x=4*3`

More Language Structures (Python)

- **Data type: values, literals, operations,** e.g., int, float, string
- **Expression** `3.1 * 2.6`
- **Call expression** `max(0, x)`
- **Variables**
- **Assignment Statement** `x = <expression>`
- **Control Statement** if … (see later)
- **Sequences: tuple, list** `(1,2), [3,4]`
  - `numpy.array( <object> )`
- **Data structures**
  - `numpy.array, Table`
- **Tuple assignment** `x,y = <expression>`

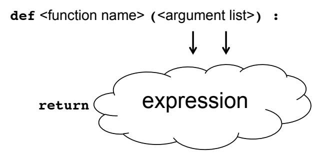
Call Expressions

- **Evaluate a function on some arguments**

What would be some useful functions?

- **Built-in functions**
  - **https://docs.python.org/3/library/functions.html**
  - `min, max, sum`
- **https://docs.python.org/3/library/**
- `str`
- `import math; help(math)`

Defining Functions



- **Generalizes an expression or set of statements to apply to lots of instances of the problem**
- **A function should *do one thing well***

Conditional statement

- **Do some statements, conditional on a *predicate* expression**

```
if <predicate>:
       <true statements>
else:
       <false statements>
```

`for` statement – iteration control

- **Repeat a block of statements for a structured sequence of variable bindings**

```
<initialization statements>
for <variables> in <sequence expression>:
  <body statements>

<rest of the program>
```

`while` statement – iteration control

- **Repeat a block of statements until a predicate expression is satisfied**

```
<initialization statements>
while <predicate expression>:
   <body statements>

<rest of the program>
```

Data-driven iteration

- **describe an expression to perform on each item in a sequence**
- **let the data dictate the control**

```
[ <expr with loop var> for <loop var> in <sequence expr > ]
```

By the Way…

- **Could we build a computer that has no instructions, only data?**

Yes! The One Instruction Set Computer.

Check it out:
https://en.wikipedia.org/wiki/One_instruction_set_computer

Questions?