Beyond the Mouse – A Short Course on Programming

2. Fundamental Programming Principles I: Variables and Data Types

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September 19, 2011

YOU'LL NEVER FIND A PROGRAMMING LANGUAGE THAT FREES YOU FROM THE BURDEN OF CLARIFYING YOUR IDEAS.
BUT I KNOW WHAT I MEAN!

“The Uncomfortable Truths Well”, http://xkcd.com/568 (April 13, 2009)

Today's schedule . . .

1. How does (computer) programming work?

2. Variables and Datatypes

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2. Variables and Datatypes

How does (computer) programming work?

Well, fist we should clearify terminology here!

What is a programming language?

What is a program?

Alright, what is it then?

Definitions (broad sense)

A **programming language** is an unambiguous artificial language that is made up of a set of symbols (vocabulary) and grammatical rules (syntax) to instruct a machine.

A **program** is a set of instructions in one or multiple programming languages that specifies the behavior of a machine.

Compilation or **interpretation** is the verification of a program and its translation into machine readable instructions of a specific platform.

Programming languages . . . continued

Two broad families can be identified:

1. **Interpreted languages**
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2. **Compiled languages**
   Programs are translated and saved in machine language. At runtime no additional program is necessary (e.g., C/C++).

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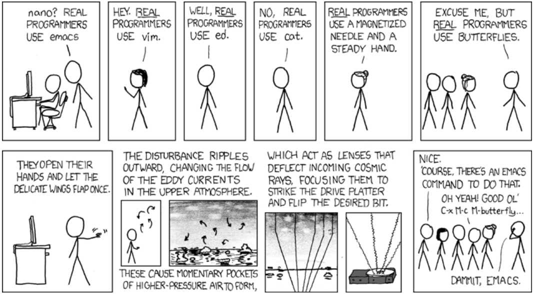

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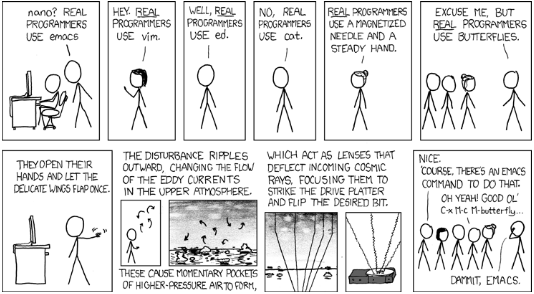
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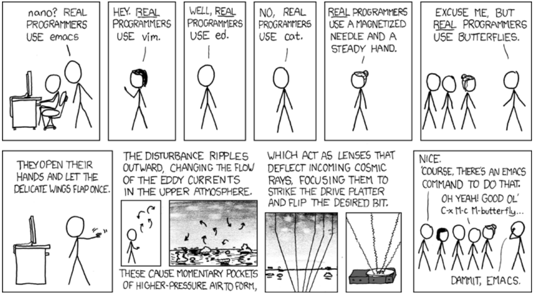
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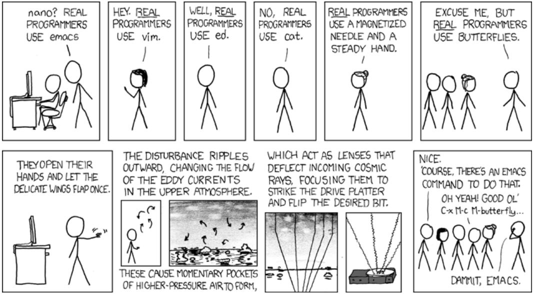

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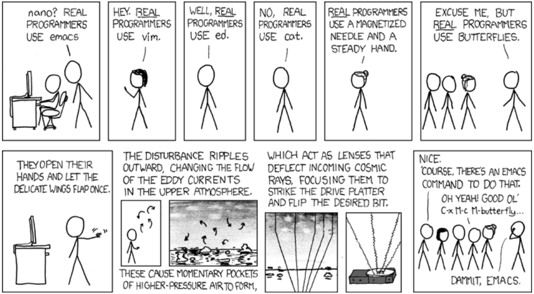
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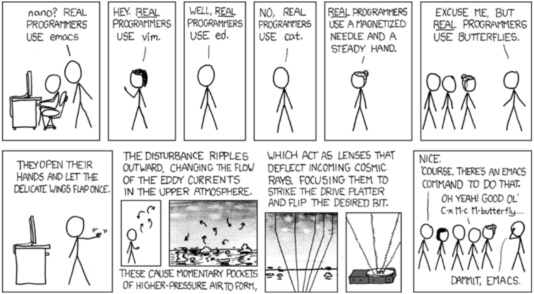
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6. if errors, fix them and go back to (3)

Don’t even think that’s as simple as it sounds . . .

‘Hello World’ in Matlab

```
>> dsp(halo orld
??? dsp(halo orld
              |
Error: Unexpected MATLAB expression.

>> dsp('halo␣orld
???␣dsp('halo orld
        |
Error: A MATLAB string constant is not terminated properly.

>> dsp('halo␣orld'
??? dsp('halo␣orld'
                    |
Error: Expression or statement is incorrect—possibly unbalanced (, {, or [.

>> dsp('halo␣orld')
??? Undefined function or method 'dsp' for input arguments of type 'char'.

>> disp('halo␣orld')
halo orld

% Sematically correct, if you want to say 'hi' to the world:
%
>> disp('hello␣world')
hello world
```

Listing 2.1: hello_world.log

Today's schedule

1. How does (computer) programming work?

2. Variables and Datatypes

Variables (1)

Definitions – a selection

Donald Knuth: A quantity that may possess different values as a program is being executed.
Mehran Sahami: A box in which we stuff things – i.e. a box with variable content.
Wikipedia: User defined keyword that is linked to a value stored in computer's **memory** (runtime).

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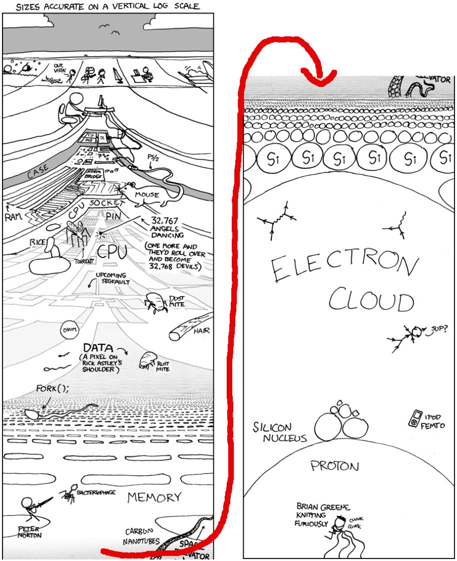
The concept of a **variable** consists of:

- name
- type
- value

Memory interlude



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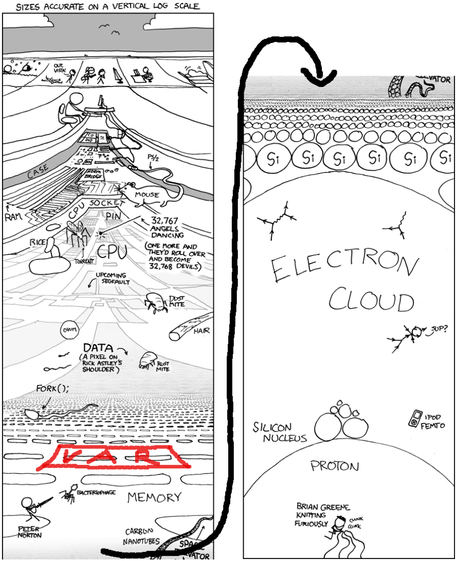

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- use consistent formatting, i.e.: ‘`my_cool_var`’ vs. ‘`myCoolVar`’ – supports reading
- a gazillion style guides exist – punchline: use meaningful names, be consistent (that’s hard enough)!

Variables (3) – type

What is a type? – Think of sets of numbers in math: $\mathbb{N}, \mathbb{R}, \mathbb{Z}, \ldots$ The type refers to how numbers are being represented in a computer's memory, i.e. which bit has which meaning, and how many bits are necessary

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Two kinds of Types

- primitive, built in types – for MATLAB e.g.: '`int32`', '`double`', '`boolean`' (important for `*printf` functions)
- complex, home made types – (arrays,) structs, cell arrays (Matlab), classes

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Types in Programming Languages

- some languages, e.g. MATLAB, Shells, Perl are weakly typed: implicit type conversions (OR one type can be treated as another)
- this is nice at first, occasionally this leads to nasty/hard to fix problems (e.g. string interpreted as number, etc.)

Variables (4) – value

Value

- a value of the type of the variable: `23, 3.1415926..., false`
- i.e., the thing we stuff in the box
- can/should change during the runtime of the program, otherwise use a constant (if possible)

Variables (4) – value

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Declaring a variable and Assigning a value:

In General: `(type) name = value;` or `(type) name = expression;`

Matlab: `myNewVar = 10;` **TC-Shell** (differs) `set myNewVar = 10;`
Access to the values (de-referencing):
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What's that?

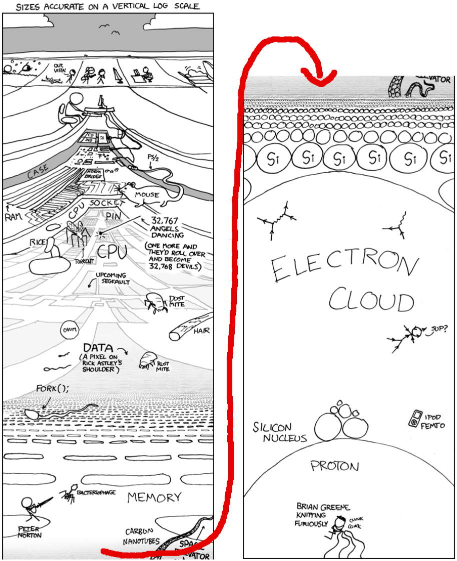
```
myNewVar = myNewVar + 1;
```

Advanced Variables: Vectors and Matrices (1)

Array variables

- are lists, vectors, matrices of data (1 to n dimensional – book keeping can become a hassle)
- therefore instead of one value they hold a **list of values**
- linked to a chunk of memory (a sequence of boxes)
- access by index number
- MATLAB treats **everything** as a matrix
- Shells allow only vectors.

Memory interlude (2)



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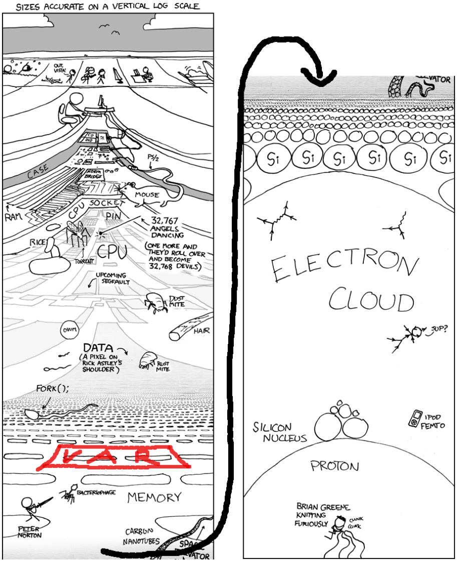

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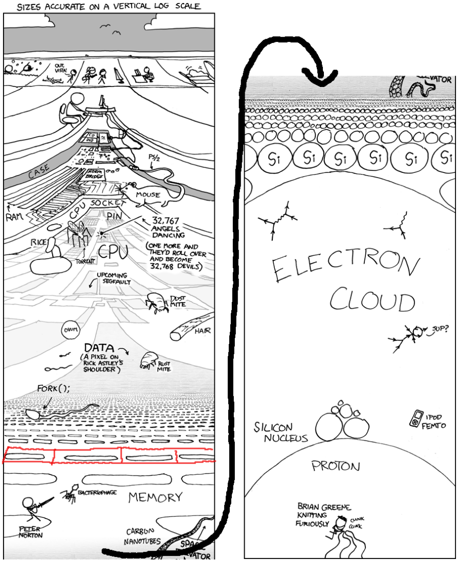

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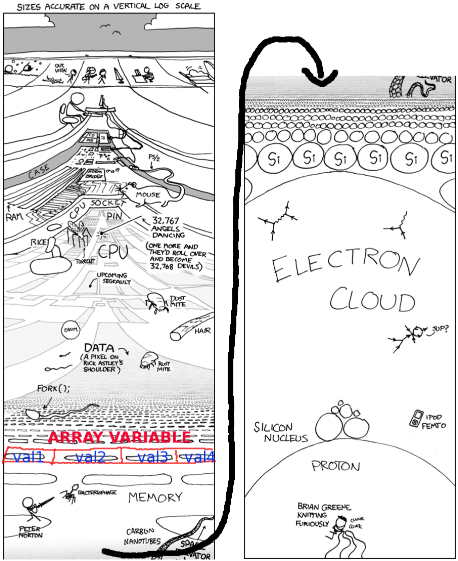

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Advanced Variables: Vectors and Matrices (2)

Example: Numeric Vector

index:	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14
vector:	12	23.3	23.3	nan	nan	1	42	42.1	23	5	nan	nan	0	0	0

Advanced Variables: Vectors and Matrices (2)

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Example: String

index:	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14
sting:	h	e	l	l	o		w	o	r	l	d	!	!	!	!

Advanced Variables: Vectors and Matrices (3)

Setting up a numeric Matrix: Equinox marathon pacing tables

index	**Mile**
1	1
2	5
3	10
4	15
5	20
6	25
7	26.2

Advanced Variables: Vectors and Matrices (3)

Setting up a numeric Matrix: Equinox marathon pacing tables

index	**Mile**	**record**
1	1	0:05:55
2	5	0:30:01
3	10	0:59:56
4	15	1:35:01
5	20	2:04:59
6	25	2:32:19
7	26.2	2:40:00

Advanced Variables: Vectors and Matrices (3)

Setting up a numeric Matrix: Equinox marathon pacing tables

index	Mile	record	well trained
1	1	0:05:55	0:08:42
2	5	0:30:01	0:44:06
3	10	0:59:56	1:28:01
4	15	1:35:01	2:19:33
5	20	2:04:59	3:03:34
6	25	2:32:19	3:43:43
7	26.2	2:40:00	3:55:00

Advanced Variables: Vectors and Matrices (3)

Setting up a numeric Matrix: Equinox marathon pacing tables

index	Mile	record	well trained	mildly trained
1	1	0:05:55	0:08:42	0:10:55
2	5	0:30:01	0:44:06	0:55:21
3	10	0:59:56	1:28:01	1:50:29
4	15	1:35:01	2:19:33	2:55:05
5	20	2:04:59	3:03:34	3:50:26
6	25	2:32:19	3:43:43	4:40:50
7	26.2	2:40:00	3:55:00	4:55:00

Example: Equinox marathon pacing table in Matlab

```
% UAF/GI   Beyond the mouse, fall 2010, Ronni Grapenthin
% EXAMPLE: 2D matrix (Table), prints list of times that can be used for optimal
% Equinox 2011 preparation
% parameter: miles — miles you've run

function pace_table = pacing_table(miles)

% Set up pacing table: Give miles as numbers and times as strings (requires a cell array,
% hence the curly braces)
pace_table = {  1     '0:05:55' '0:08:42' '0:10:55';
                5     '0:30:01' '0:44:06' '0:55:21';
                10    '0:59:56' '1:28:01' '1:50:29';
                15    '1:35:01' '2:19:33' '2:55:05';
                20    '2:04:59' '3:03:34' '3:50:26';
                26.2  '2:40:00' '3:55:00' '4:55:00'};


% Since I'm lazy and didn't want to type all the miles, a mile does not equal the index,
% hence we'll have to do some math. Index is rounded number of miles divided by 5. Since
% Matlab indices start at 1, we have to add a 1. Otherwise everything smaller than 2.5 miles
% would result in an error
idx = round(miles/5)+1;

% lame output
pace_table(idx,:)
pause

% fancy output:
disp('␣');
disp('␣␣␣miles␣␣␣␣record␣␣␣␣well␣trained␣␣mildly␣trained');
disp('␣␣------------------------------------------------------------');
disp(pace_table(idx,:));
end
```

Listing 2.2: pacing_table.m