RSE Computational Economics Workshop

An introduction to computational methods
for economics and finance

10:00am – 12:00am 22nd July 2022

Personel

- Aakash Choudhury (RSE, Developer)
- Shu Hu (RSE, PhD student)
- John Stachurski (RSE, Professor)

Topics

- Introduction to Scientific Computing
- Installation of Anaconda Python
- Working with Data
- High Performance Computing

Assumptions:

- econ/computer/maths/stats literate
- some basic familiarity with computers

Aims:

- Discuss options
- See what's possible

Resources

- `https://github.com/QuantEcon/rse_comp_econ_2022`

Background — Language Types

Proprietary

- Excel
- MATLAB
- STATA, etc.

Open Source

- Python
- Julia
- R

closed and stable vs open and fast moving

Background — Language Types

Low level

- C/C++
- Fortran
- Rust

High level

- Python
- Ruby
- TypeScript

Low level languages give us fine grained control

Example. $1 + 1$ in assembly

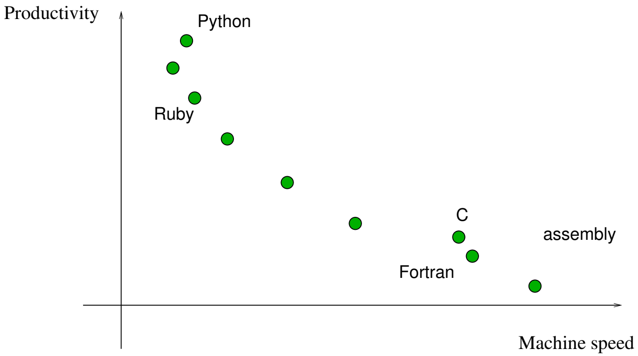
```
pushq    %rbp
movq     %rsp, %rbp
movl     $1, -12(%rbp)
movl     $1, -8(%rbp)
movl     -12(%rbp), %edx
movl     -8(%rbp), %eax
addl     %edx, %eax
movl     %eax, -4(%rbp)
movl     -4(%rbp), %eax
popq     %rbp
```

High level languages give us abstraction, automation, etc.

Example. Reading from a file in Python

```
data_file = open("data.txt")
for line in data_file:
    print(line.capitalize())
data_file.close()
```

Trade-Offs

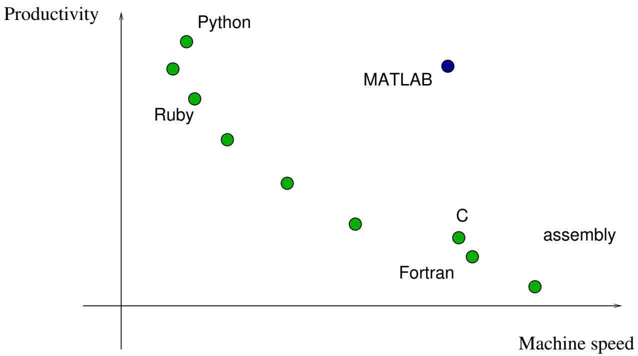

Productivity
Python
Ruby
C
assembly
Fortran
Machine speed

But what about scientific computing?

Requirements

- Productive — easy to read, write, debug, explore
- Fast computations

Trade-Offs


Productivity
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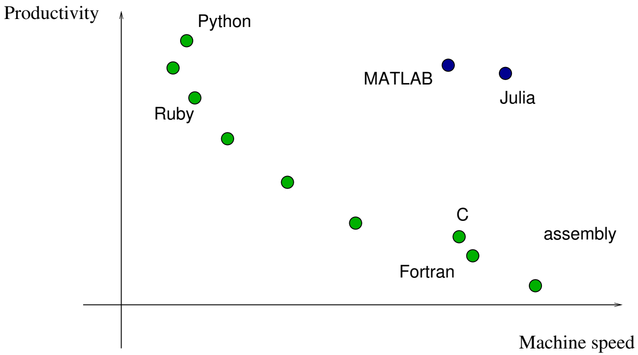
Trade-Offs


Productivity
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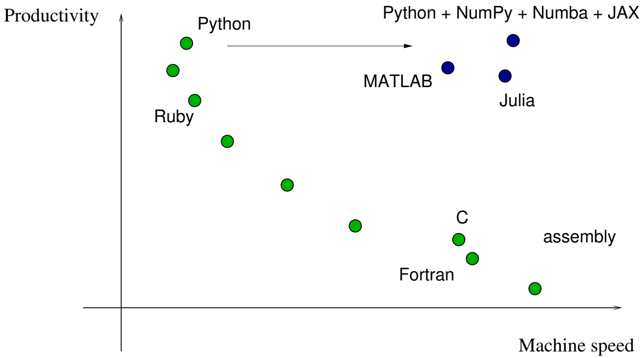
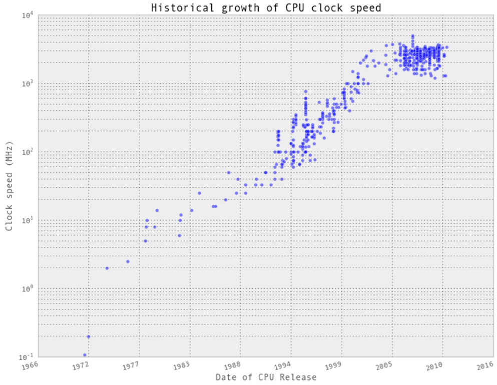
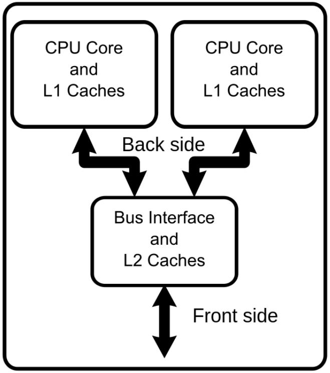

Productivity
Python
Python + NumPy + Numba + JAX
MATLAB
Julia
Ruby
C
assembly
Fortran
Machine speed

Trend 1: Parallelization

CPU frequency (clock speed) growth is slowing

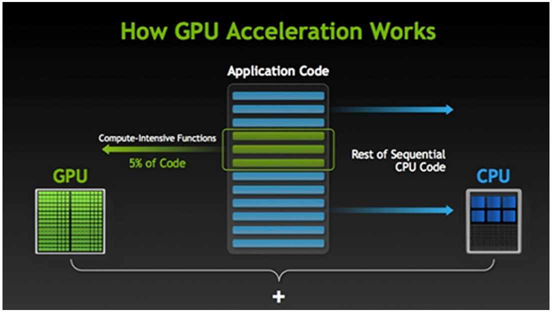


Chip makers have responded by developing multi-core processors



Source: Wikipedia

GPUs / **ASICs** are also becoming increasingly important


How GPU Acceleration Works
Application Code
Compute-Intensive Functions
5% of Code
GPU
Rest of Sequential CPU Code
CPU
+

Applications: machine learning, deep learning, etc.

Trend 2: Distributed Computing

Advantages:

- run code on big machines we don't have to buy
- customized execution environments
- circumvent annoying internal IT departments

Options:

- University machines
- AWS
- Google Colab, etc.

Which Language

How about R?

- Specialized to statistics
- Easy to learn, well designed
- Huge range of estimation routines
- Significant demand for R programmers
- Popular in academia

However loosing ground to Python

Example. Chris Wiggins, Chief Data Scientist at The New York Times:

“Python has gotten sufficiently weapons grade that we don’t descend into R anymore. Sorry, R people. I used to be one of you but we no longer descend into R.”

Julia

Pros:

- Fast and elegant
- Many scientific routines
- Julia is written in Julia

Cons:

- Some stability issues
- Failing to achieve rapid growth

Python

- Easy to learn, well designed
- Massive scientific ecosystem
- Heavily supported by big players
- Open source
- Huge demand for tech-savvy Python programmers

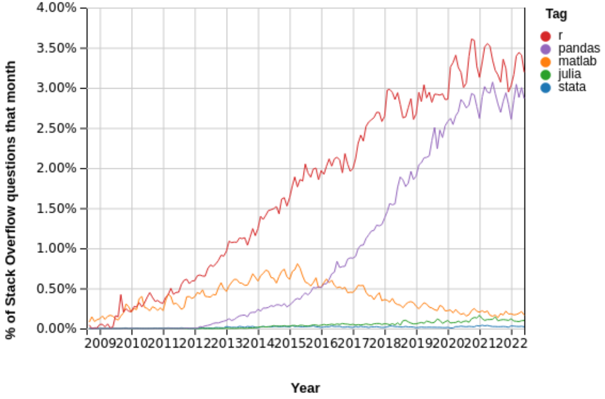
Scientific Computing

Python has strong tools in vectorization / JIT compilation / parallelization / visualization / etc.

Examples:

- SciPy, NumPy, Matplotlib, pandas
- Numba (JIT compilation, multithreading)
- Tensorflow, PyTorch (machine learning, AI)
- JAX (JIT compilation, parallelization), etc., etc.

Popularity, others vs one Python library (pandas)



Downloads / Installation / Troubleshooting

Install Python + Scientific Libs (Optional!)

- Install Anaconda from `https://www.anaconda.com/`
    - Select latest version
    - For your OS
    - Say “yes” at prompts
- Not plain vanilla Python

Remote options

- `https://colab.research.google.com`
- `https://www.pythonanywhere.com/`

Jupyter Notebooks

A browser based interface to Python / Julia / R / etc.

- Search for `jupyter notebook`

Useful for:

- getting started
- exploring ideas

Working with Notebooks

- Entry and execution
- Markdown
- Getting help
- Copy paste
- Edit and command mode