Python tutorial

Tips and tricks you may already know…

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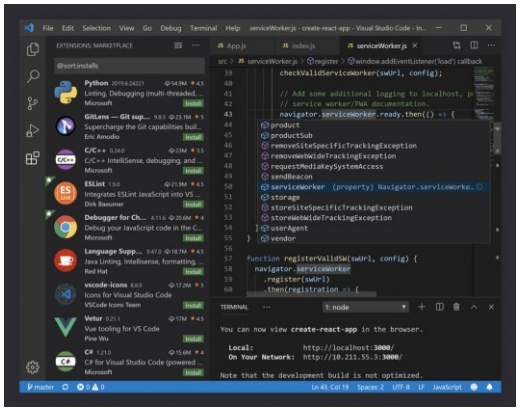
Summary

- Coding:
  What is it really about?

- In the beginning…
  There was an IDE



- Python:
  must know

$$A \to B$$
$$C \to D$$
$$E \to F$$

Disclaimer

- This lecture **is not about**:
  - Coding from the scratch
  - Advanced coding/python
- This lecture **is about**:
  - Giving a hands-on intro…

Coding: what is it about?

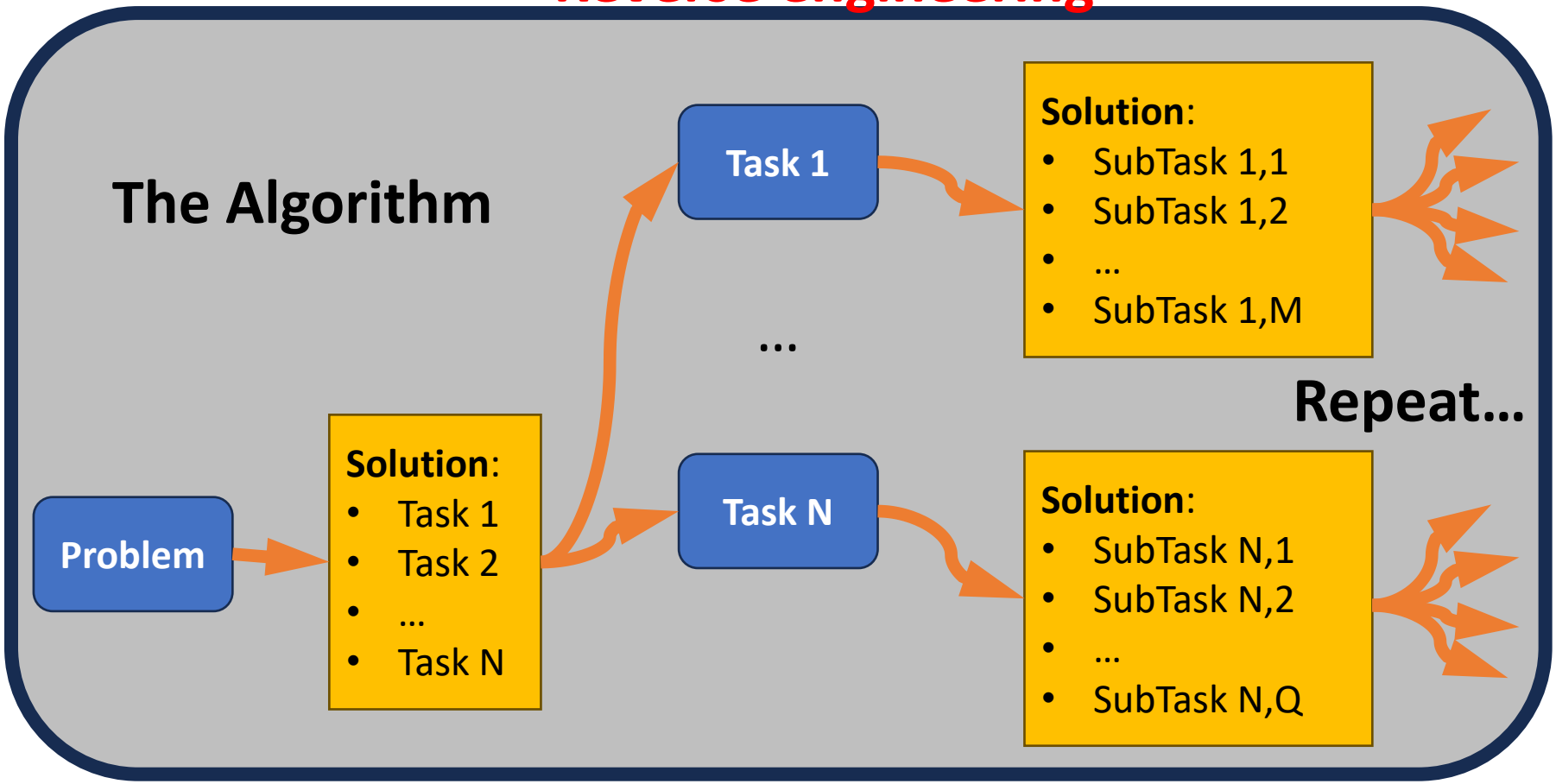
- **Solving problems** you didn’t know you had!

Coding: what is it about?

- If you **can make a sandwich**, you **can code**!

a.k.a.

"Reverse engineering"



Coding: what is it about?

- If you **can make a sandwich**, you **can code**!

```
from kitchen import SandwichMaker,fridge

sandwich = SandwichMaker()

if sandwich.is_vegan():
    stuffing = fridge.get_available_vegs()
else:
    stuffing = fridge.get_everything()

sandwich.open() # we need to open the bread!
for item in stuffing:
    sandwich.add(item) # add stuff
sandwich.close() # and then close it!

grill(sandwich,temperature=150*Celsius)
eat(sandwich)
```

Coding: elements…

- **Statements**:

Tells the "interpreter" what to do

E.g.:

- Create variables
- Check conditions
- Iterate over array
- Import stuff
- …

Each line here!

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Coding: elements…

- **Functions**:

Transform some values into other values

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Coding: elements…

- **Variables**:

names that hold values… (i.e., "boxes")

They are assigned with the "=" operator

- int
- float
- str
- numpy.ndarray
- SandwichMaker

- **Types**:

Define what a variable can hold

- **Objects**:

Special variables that hold *abstract* **Types**

- **Classes**:

Statements that define *abstract* **Types**

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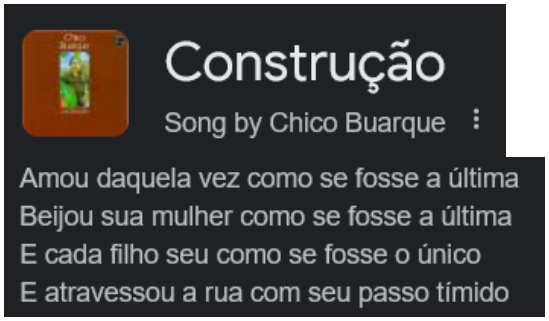
Coding: elements…



- Remember:

A **programming language** is a

Formal Language not Poetry

i.e. no ambiguity; only "one way" of writing it; writing rules are strict (syntax is "absolute")

```
1  "111" + 10

---------------------------------------------------------------------------
TypeError                                 Traceback (most recent call last)
Cell In[14], line 1
----> 1 "111" + 10

TypeError: can only concatenate str (not "int") to str
```

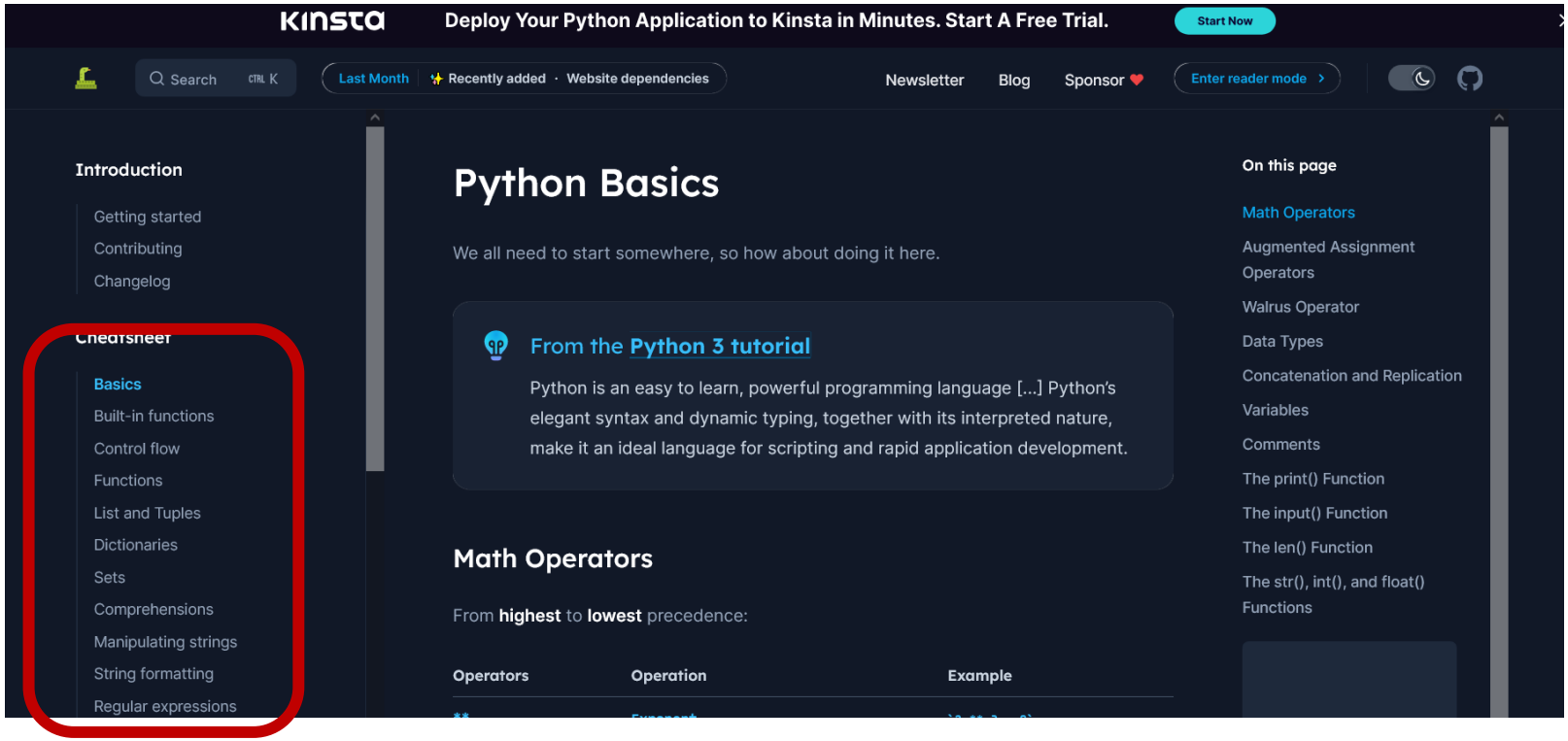
- **Errors will happen**

Don't avoid them, **read** and **understand**!

- **ChatGPT/Google/Stackoverflow** can help. **Use with caution**. Use clever queries with proper "keywords"

Coding: elements…

- Python cheat sheet: https://www.pythoncheatsheet.org/cheatsheet/basics



Coding: elements…

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Math Operators

From **highest** to **lowest** precedence:

Operators	Operation	Example
`**`	Exponent	`` `2 ** 3 = 8` ``
`%`	Modulus/Remainder	`` `22 % 8 = 6` ``
`//`	Integer division	`` `22 // 8 = 2` ``
`/`	Division	`` `22 / 8 = 2.75` ``
`*`	Multiplication	`` `3 * 3 = 9` ``
`-`	Subtraction	`` `5 - 2 = 3` ``
`+`	Addition	`` `2 + 2 = 4` ``

Coding: elements…

- Python cheat sheet: https://www.pythoncheatsheet.org/cheatsheet/built-in-functions

Recently added · Website dependencies

Python built-in Functions

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Function	Description
abs()	Return the absolute value of a number.
aiter()	Return an asynchronous iterator for an asynchronous iterable.
all()	Return True if all elements of the iterable are true.
any()	Return True if any element of the iterable is true.
ascii()	Return a string with a printable representation of an object.
bin()	Convert an integer number to a binary string.
bool()	Return a Boolean value.
breakpoint()	Drops you into the debugger at the call site.
bytearray()	Return a new array of bytes.
bytes()	Return a new “bytes” object.
callable()	Return True if the object argument is callable, False if not.

etc

Coding: elements…

- Python cheat sheet: https://www.pythoncheatsheet.org/cheatsheet/control-flow

Comparison Operators

Operator	Meaning
`==`	Equal to
`!=`	Not equal to
`<`	Less than
`>`	Greater Than
`<=`	Less than or Equal to
`>=`	Greater than or Equal to

Boolean Operators

There are three Boolean operators: `and`, `or`, and `not`. In the order of precedence, highest to lowest they are `not`, `and` and `or`.

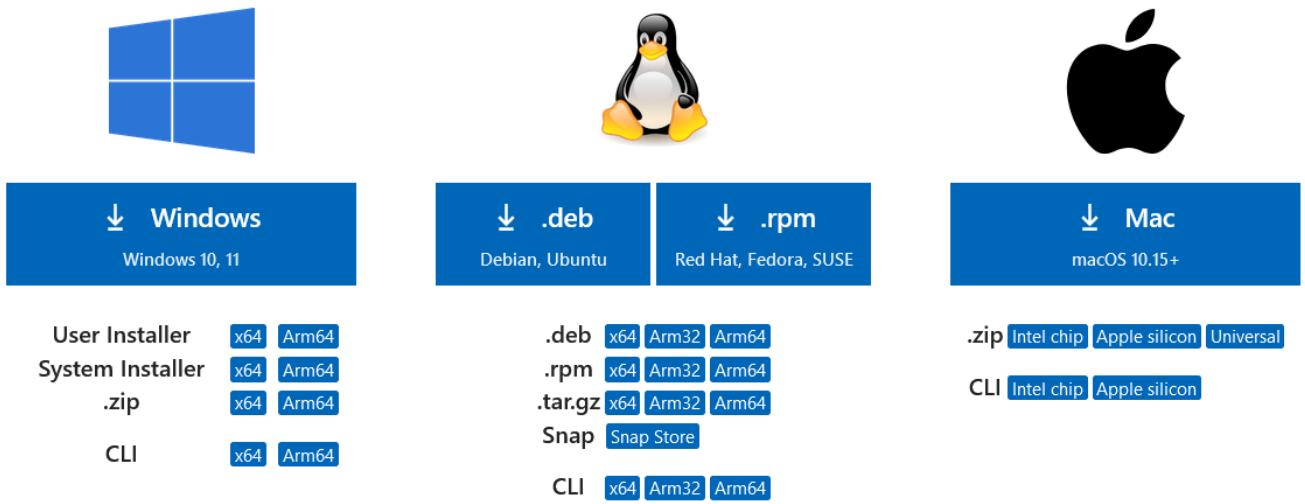
etc

Coding: elements…

- Python cheat sheet:
  - https://www.pythoncheatsheet.org/cheatsheet/functions
  - https://www.pythoncheatsheet.org/cheatsheet/lists-and-tuples
  - https://www.pythoncheatsheet.org/cheatsheet/dictionaries
  - https://www.pythoncheatsheet.org/cheatsheet/sets
  - https://www.pythoncheatsheet.org/cheatsheet/comprehensions
  - https://www.pythoncheatsheet.org/cheatsheet/string-formatting

In the beginning… There was an IDE

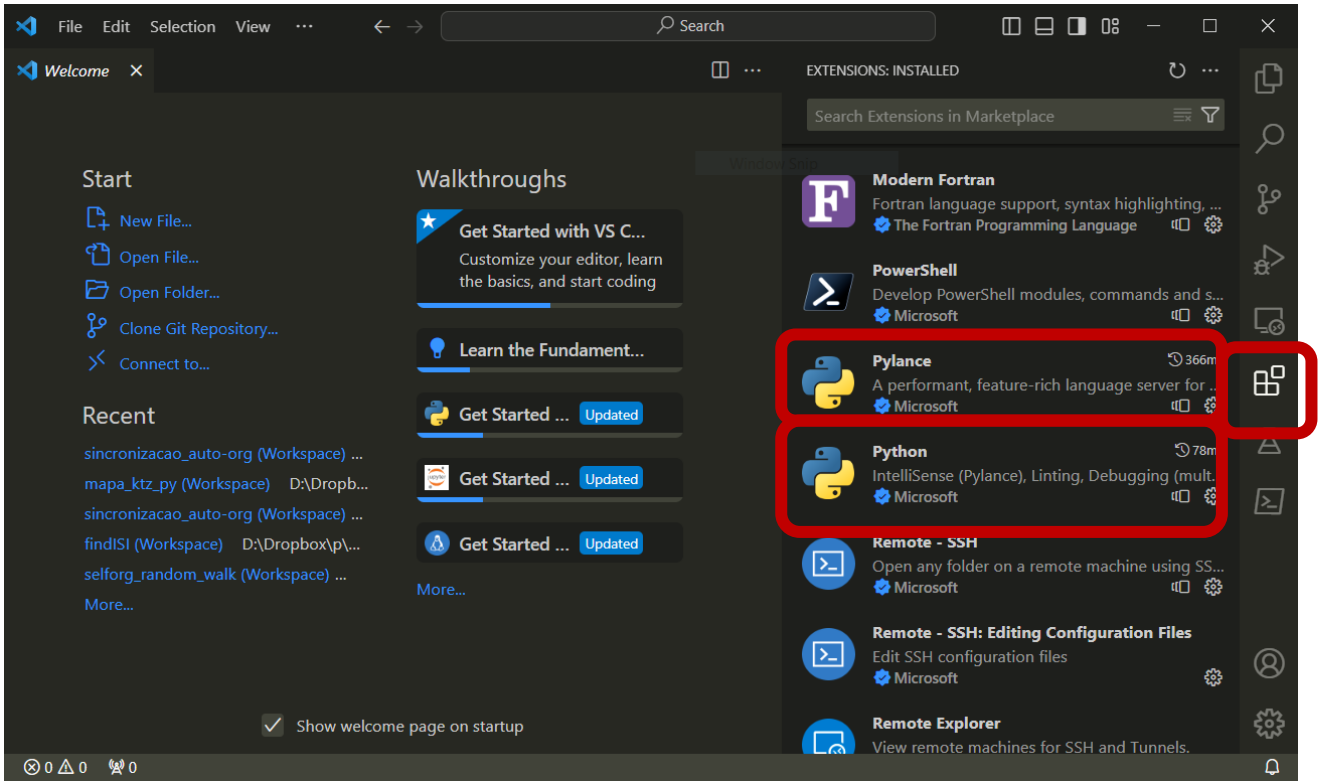
- VS Code
  https://code.visualstudio.com/#alt-downloads



Lightweight, Intellisense (suggestions/corrections of code snippets), syntax highlighting, Jupyter integrated support (view variable workspace on the fly)

In the beginning… There was an IDE

- Python in VS Code: https://code.visualstudio.com/docs/languages/python



- Python
- Pylance

In the beginning… There was an IDE

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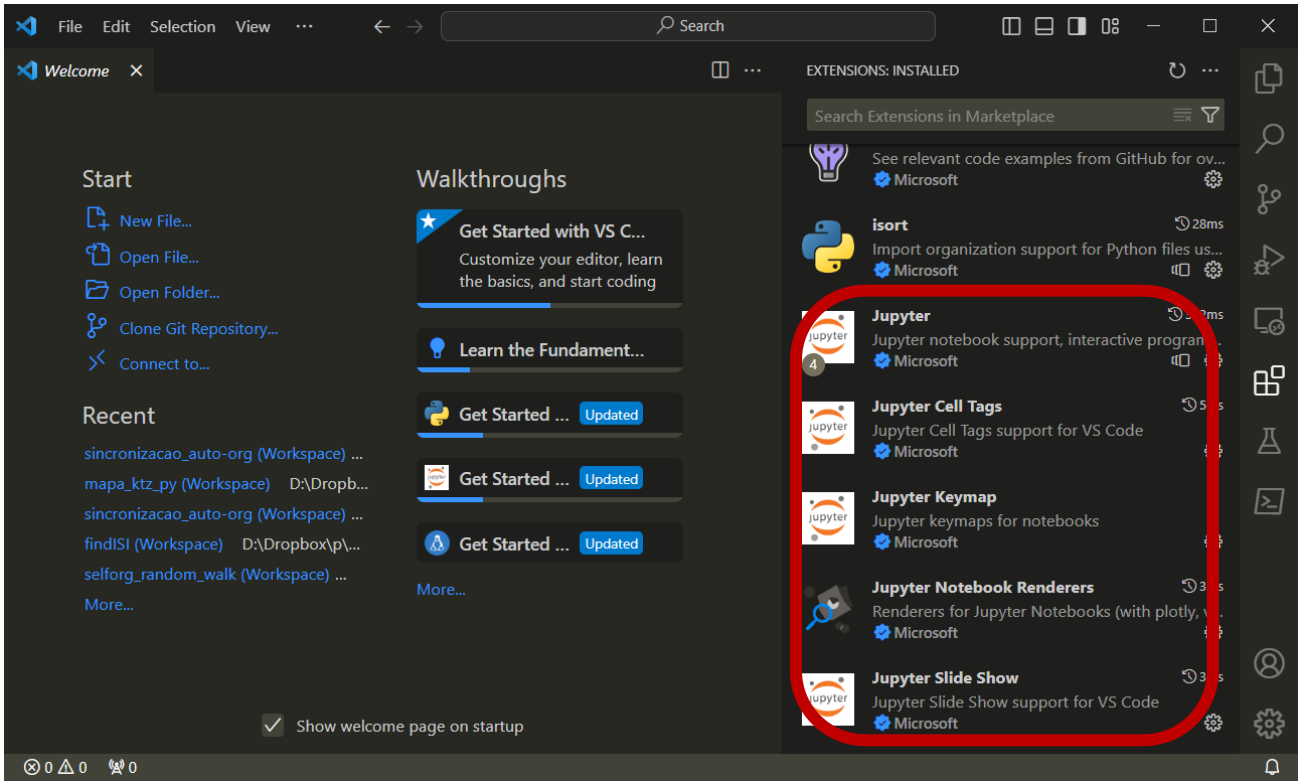


- Python
- Pylance
- Jupyter
- Other Jupyter related

Python: must know

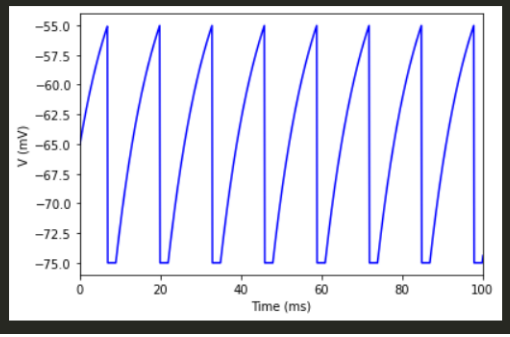
- Python is not a “go-to” language for performance!
- Python is optimized for user-friendliness

- **Jupyter -> literally a “notebook”**
  - Code executed by parts
  - You can mix code with annotations
  - Direct visual I/O feedback of your code
  - Good for plotting
  - Good for probing unknown problems
  - Usually worse performance
  - Runs in the browser or in VS Code

Constant current

Execute the following cell to run the LIF neuron when receiving a DC curre

```
pars = default_pars()
v, rec_spikes = run_LIF(pars, I = 300.)
plt.plot(pars['range_t'], v, 'b')
plt.xlim(0, 100)
plt.xlabel('Time (ms)')
plt.ylabel('V (mV)');
```



- **Scripting -> more like an “old school program”**
  - Write all the code -> run all at once
  - Another script needed to analyze the data
  - Better when you need performance
  - Run from the terminal: python myscript.py
  - Useful tools for performance gain: **numba**, **pythran**, **cython**, **f2py**

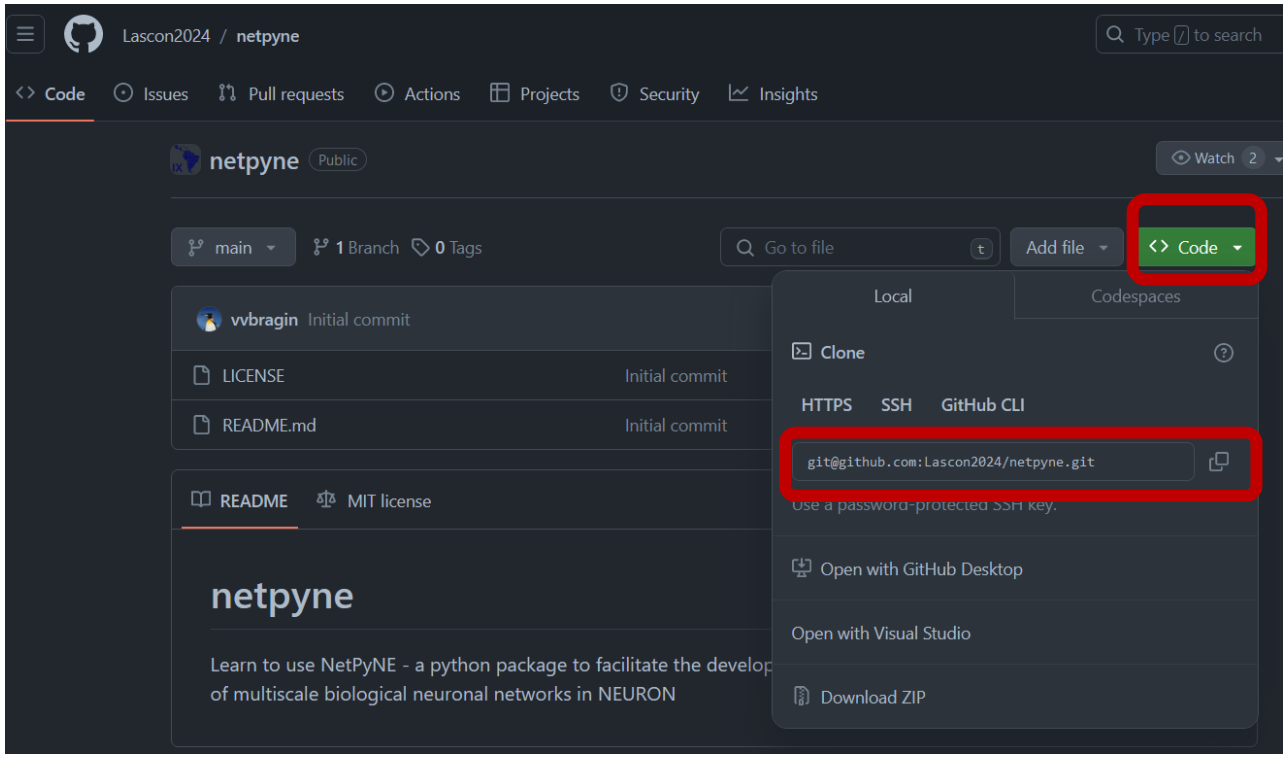
```
import quantities
import modules.output as output
import modules.neurons as neu
import modules.plot as p
import modules.input as inp
import modules.misc as misc

parser = argparse.ArgumentParser(description='Run c
parser = inp.add_neuron_parameters(parser)
#parser = inp.add_neuronparamset_parameters(parser)
#parser = inp.add_stimulus_parameters(parser,tStim=
parser = inp.add_stimulus_parameters(parser,tStim=[
#parser = inp.add_stimulus_parameters(parser,tStim=
parser = inp.add_output_parameters(parser,out=['cur
parser = inp.add_simulation_parameters(parser,T=[50
parser.add_argument('-show', required=False, action
parser.add_argument('-savefig', required=False, act
parser.add_argument('-savevoltage', required=False,

args = parser.parse_args()
saveData = args.save
saveVoltage = args.savevoltage
saveFig = args.savefig
```

Python: must know

- git https://github.com/Lascon2024

cd ~/my/lascon2024/netpyne

git clone git@github.com:Lascon2024/netpyne.git .



Python: must know

- **numpy**: MATLAB-like vector/matrix manipulation
  https://numpy.org/doc/stable/user/quickstart.html

```
>>> a = np.array(1, 2, 3, 4)    # WRONG
Traceback (most recent call last):
  ...
TypeError: array() takes from 1 to 2 positional arguments but 4 were given
>>> a = np.array([1, 2, 3, 4])  # RIGHT
```

```
>>> import numpy as np
>>> a = np.arange(15).reshape(3, 5)
>>> a
array([[ 0,  1,  2,  3,  4],
       [ 5,  6,  7,  8,  9],
       [10, 11, 12, 13, 14]])
>>> a.shape
(3, 5)
>>> a.ndim
2
>>> a.dtype.name
'int64'
>>> a.itemsize
8
>>> a.size
15
>>> type(a)
<class 'numpy.ndarray'>
>>> b = np.array([6, 7, 8])
>>> b
array([6, 7, 8])
>>> type(b)
<class 'numpy.ndarray'>
```

Python: must know

- **scipy**: Scientific/math codes (based on numpy) https://docs.scipy.org/doc/scipy/tutorial/index.html
  - Interpolation (fill missing data gaps): **scipy.interpolate**
  - Statistics: **scipy.stats** (T-test, chi-squared, etc)
  - Signal processing: **scipy.signal** (Filters, find peaks, spectra)
  - Optimization: **scipy.optimize** (curve fitting, parameter estimation)
  - Integration: **scipy.integrate** (Simpson, trapezoid, etc)
  - Sparse matrices: **scipy.sparse** (large data arrays with mostly zeros)
  - I/O: **scipy.io** (savemat, loadmat -> integration with MATLAB; easy data storage – better than numpy's, and more widely compatible)

SciPy User Guide

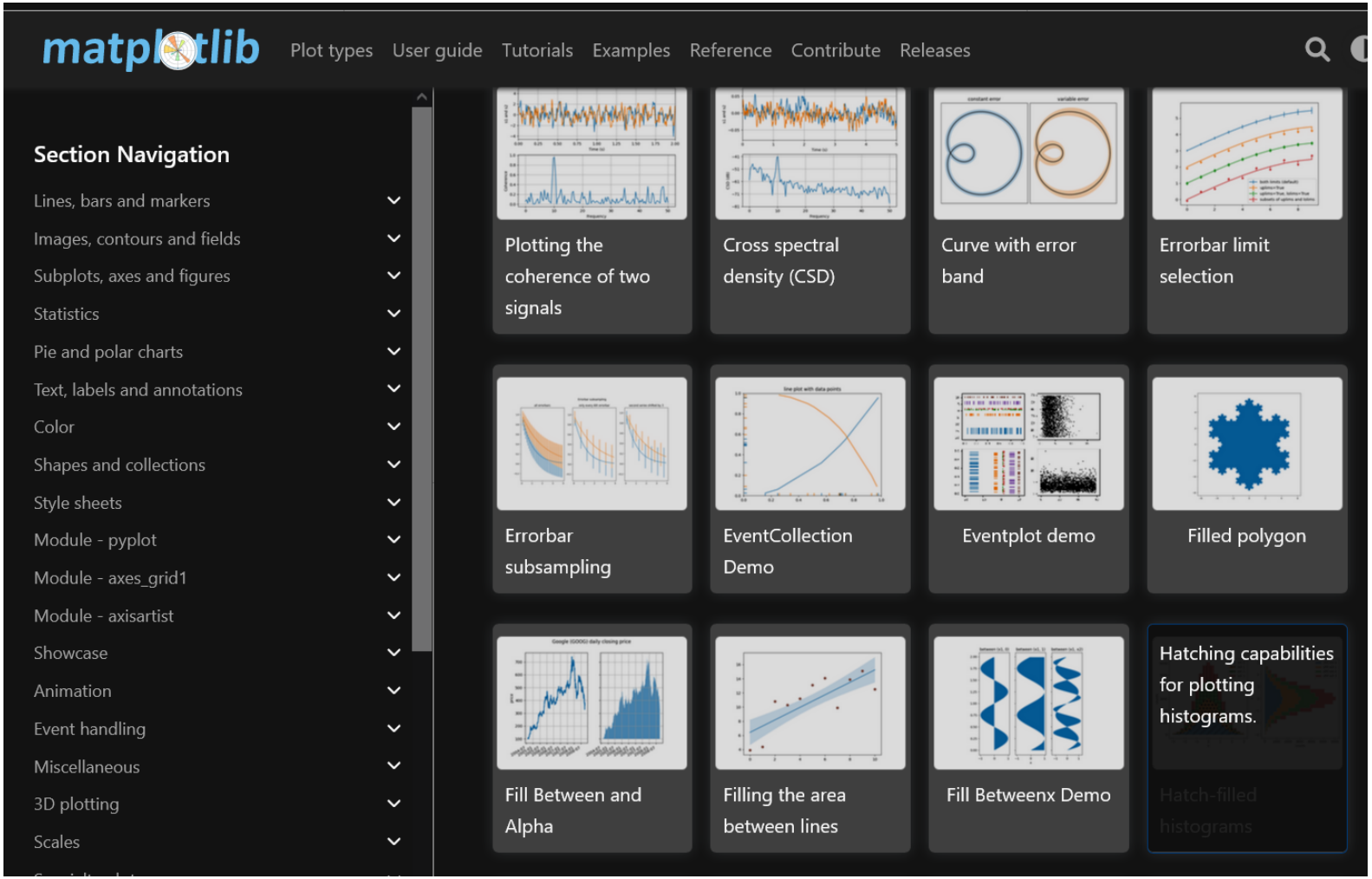
SciPy is a collection of mathematical algorithms and convenience functions built on NumPy . It adds significant power to Python by providing the user with high-level commands and classes for manipulating and visualizing data.

Subpackages

SciPy is organized into subpackages covering different scientific computing domains. These are summarized in the following table:

Python: must know

- **Matplotlib**: MATLAB-like figure plotting capabilities
  https://matplotlib.org/stable/gallery/index.html



Python: must know

- **pandas**: data science toolkit…
  CSV and Excel file I/O (main features to me :P)
  https://pandas.pydata.org/docs/user_guide/10min.html

pandas.read_excel

```
pandas.read_excel(io, sheet_name=0, *, header=0, names=None, index_col=None,
usecols=None, dtype=None, engine=None, converters=None, true_values=None,
false_values=None, skiprows=None, nrows=None, na_values=None,
keep_default_na=True, na_filter=True, verbose=False, parse_dates=False,
date_parser=_NoDefault.no_default, date_format=None, thousands=None, decimal='.',
comment=None, skipfooter=0, storage_options=None,
dtype_backend=_NoDefault.no_default, engine_kwargs=None)
```

[source]

Further learning…

- Our git repo:
  https://github.com/Lascon2024/python-tutorial

- Scientific python lectures (Scipy, numpy examples)
  https://github.com/jrjohansson/scientific-python-lectures/tree/master

- Beginner concepts:
  The way of the program:
  https://greenteapress.com/thinkpython2/html/thinkpython2002.html
  Variables, expressions, statements:
  https://greenteapress.com/thinkpython2/html/thinkpython2003.html

- Intro to python:
  https://cs111.wellesley.edu/lectures/lec_python_intro/

Example…

Leaky IF neuron:

$$\tau \frac{dV}{dt} = V_b - V + RI$$

If $V = \theta$

$$V(t) = 60\ mV$$
$$V(t + dt) = V_0$$

- Determine the problem
- Identify parameters
- Identify variables

Quadratic IF neuron:

$$C \frac{dV}{dt} = G(V - V_r)(V - V_c) + I$$

If $V = \theta$

$$V(t) = 60\ mV$$
$$V(t + dt) = V_0$$