### NumPy Vectorization

This lesson teaches Numpy vectorization and explains it with a simple example using object-oriented, procedural and vectorized approach.

#### WE'LL COVER THE FOLLOWING ^

- Object Oriented Approach
- Procedural Approach
- Vectorized Approach
  - 1. Itertools
  - 2. Numpy

*Vectorization*, in simple words, means optimizing the algorithm so that it can run multiple operations from a single instruction. NumPy is all about vectorization. If you are familiar with Python, this is the main difficulty you'll face because you'll need to change your way of thinking and your new friends (among others) are named "vectors", "arrays", "views" or "ufuncs".

**Note:** A custom magic command timeit is used in all codes. It's a tool for measuring the execution time of small code snippets.

# Object Oriented Approach #

Let's take a very simple example, a random walk. One possible object-oriented approach would be to define a RandomWalker class and write a walk method that would return the current position after each (random) step. It's nice, it's readable, but it is slow:



```
from tools import timeit #get time it from tools.py(custom module)
import random
class RandomWalker:
  def __init__(self):
           self.position = 0
  def walk(self, n): # walk method
    self.position = 0
   for i in range(n):
      yield self.position
      self.position += 2*random.randint(0, 1) - 1
      #returns current position after each random step
walker = RandomWalker() # make instance of class walk
walk = [position for position in walker.walk(1000)]#call the walk function
walker = RandomWalker()
timeit("[position for position in walker.walk(n=10000)]", globals())
#calculates the total loops and time per loop
                                                                            \triangleright
```

Here loops are the total number of CPU cycles required during a random walk and the time in msec indicates time per cycle.

# Procedural Approach #

For such a simple problem, we can probably save the class definition and concentrate only on the walk method that computes successive positions after each random step. This new method saves some CPU cycles but not that much because of this function is pretty much the same as in the object-oriented approach and the few cycles we saved probably come from the inner Python object-oriented machinery.

main.py		G
tools.py		
<pre>from tools import timeit #get timeit from tools.py (custom module) import random def random_walk(n):     position = 0     walk = [position]     for i in range(n):         position += 2*random.randint(0, 1)-1 #position takes up random values         walk.append(position)# append position to walk     return walk</pre>		

```
walk = random_walk(1000) #call the function random_walk
timeit("random_walk(n=10000)", globals()) # calculates the total loops and time per loop
```

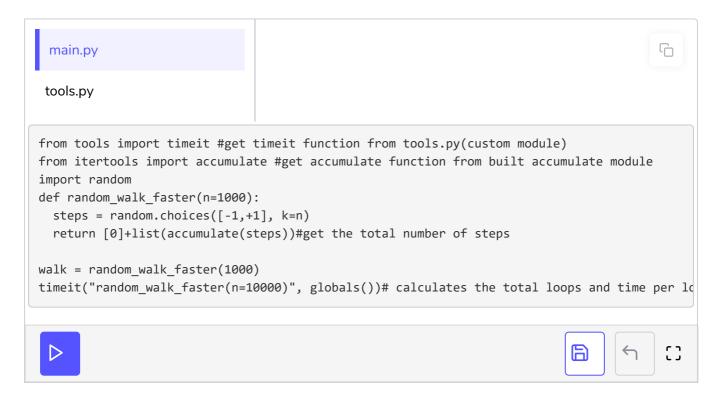
Here we can see that the time taken by the procedural approach is less than that of the object-oriented approach.

# Vectorized Approach #

For the vectorized approach, we can use Itertools or NumPy.

#### 1. Itertools #

Itertools is a python module that offers *a set of functions creating iterators for efficient looping*. If we observe that a random walk is an accumulation of steps, we can rewrite the function by first generating all the steps and accumulate them without any loop:



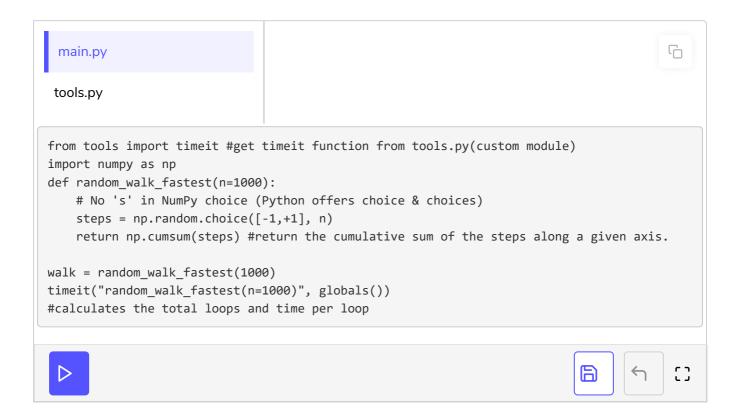
In fact, we've just *vectorized* our function. Instead of looping for picking sequential steps and add them to the current position, we first generated all the steps at once and used the accumulate function to compute all the positions. We got rid of the loop and this makes things faster.

#### 2. Numpy #

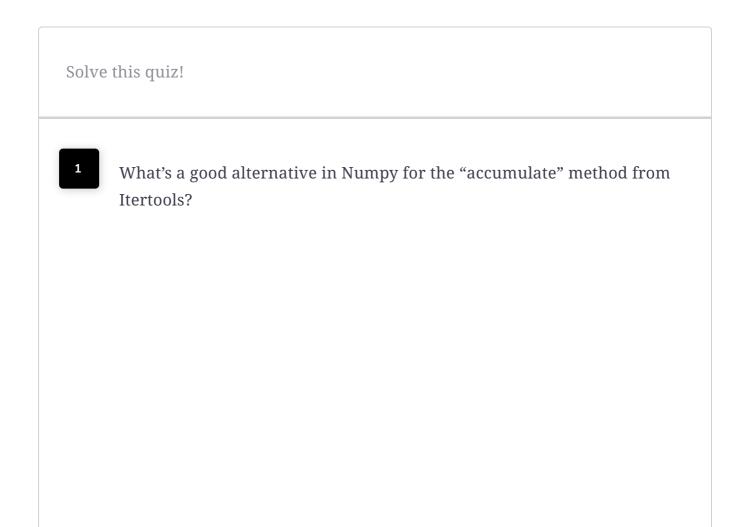
We gained 85% of computation-time compared to the previous version, not so

bad. But the advantage of this new version is that it makes NumPy

vectorization super simple. We just have to translate itertools call into NumPy ones:



Not too difficult, but we gained a factor 500x using NumPy.



This course is about vectorization, be it at the code or problem level. We'll see this difference is important before looking at custom vectorization.

In the next lesson, we'll learn about "Readability vs. Speed".