What is functional programming?

PROGRAMMING PARADIGM CONCEPTS

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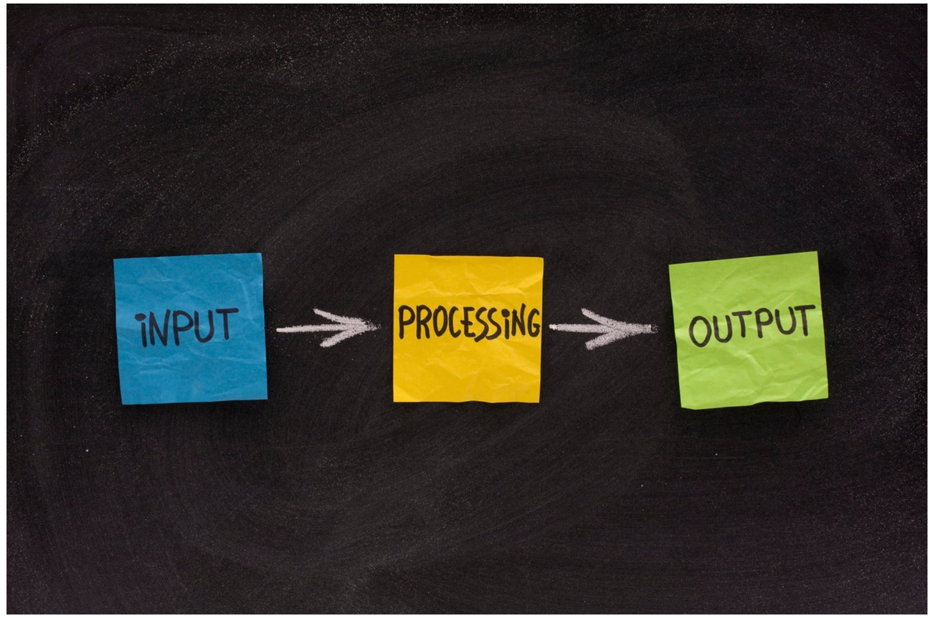
What is functional programming?

- **Functional programming:** a programming paradigm involving functions, specifically *pure functions*
- **Pure functions:** a process that takes input values, produces output values based only on the input values, and does not do anything else
- **Separation of responsibilities** is achieved in functional programming via functions



What is a pure function?

- Concept of **pure function** in functional programming comes from mathematics
- Pure functions only *look at input* and only *produce output*
- Pure functions have no **"side effects"**

- **No side effects** means:
  - No influence on other variables in the program
  - No writing to files
  - No saving information to a database

Example of a pure function

Pure function

```python
def pure_sum(x, y):
    output = x + y

    return output
```

Not a pure function

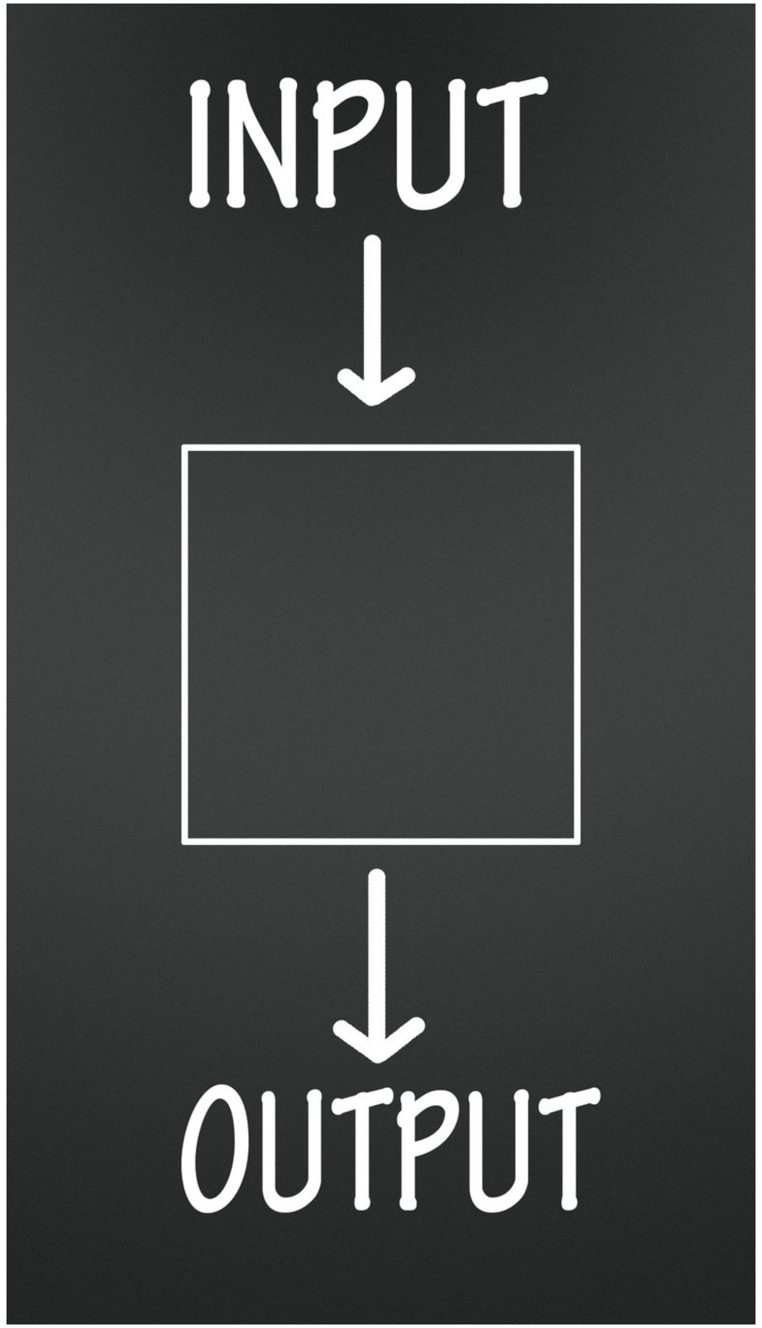
```python
def not_pure_sum(x, y):
    output = x + y

    print(output)

    return output
```

Benefits of pure functions

- Pure functions are easier to understand and debug
- Testing of pure functions is easier
- Output for a given input is entirely predictable
    - Similar to mathematical functions: 5 squared is always 25



Let's practice!

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When is functional programming used?

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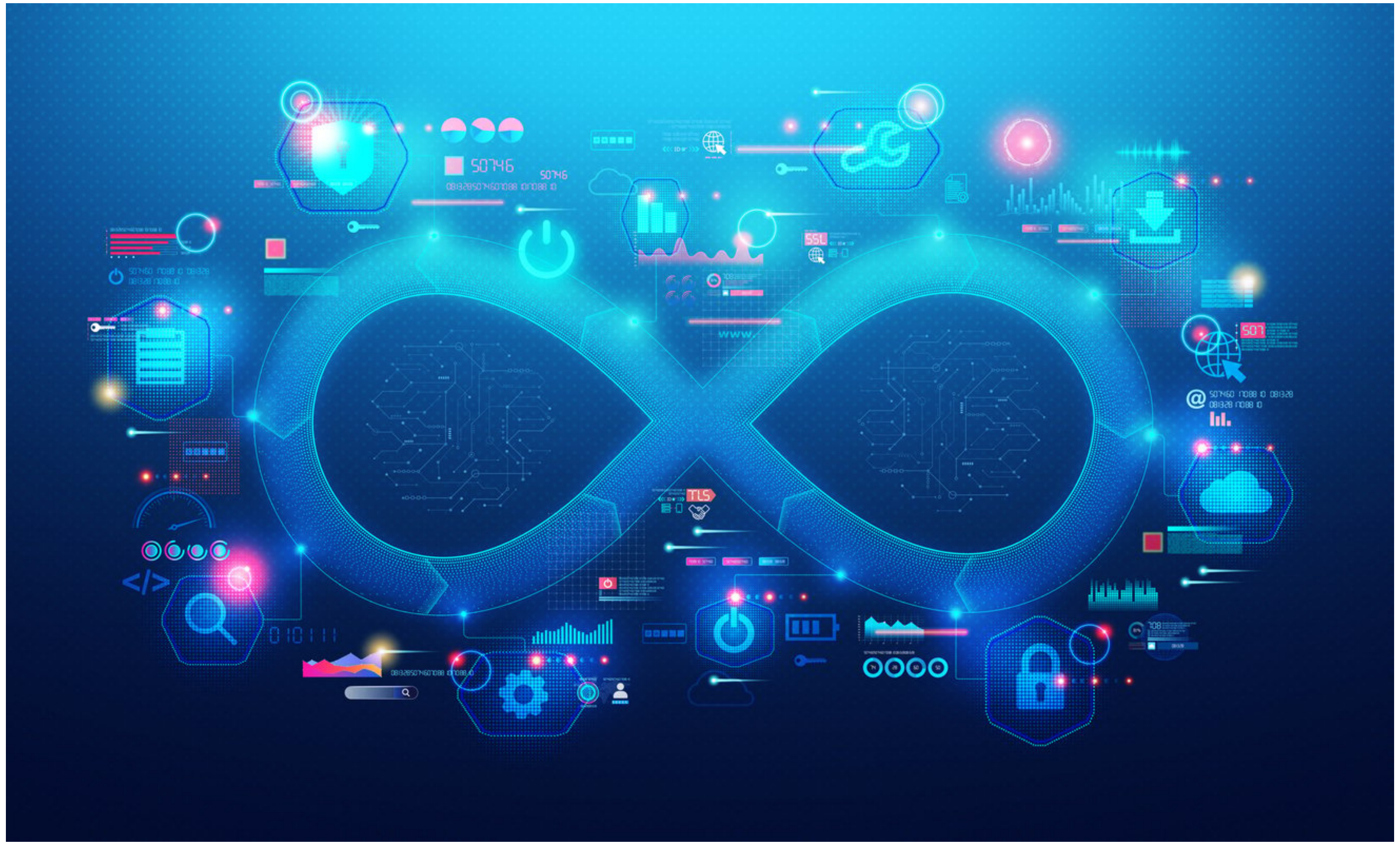
Applications of functional programming

- Machine learning, deep learning, artificial intelligence
- Analyzing and processing large datasets
- Data engineering applications (e.g. in Scala and Clojure)



Example of functional programming

```
def process_data(raw_data):
    processed_data = raw_data

    ... further processing steps here! ...

    return processed_data
```

- Function takes input data stored in `raw_data`
- Function creates new variable for output data, called `processed_data`
- Function performs some consistent set of steps to further process the data
- Function returns `processed_data`

Pros and cons of functional programming

PROS

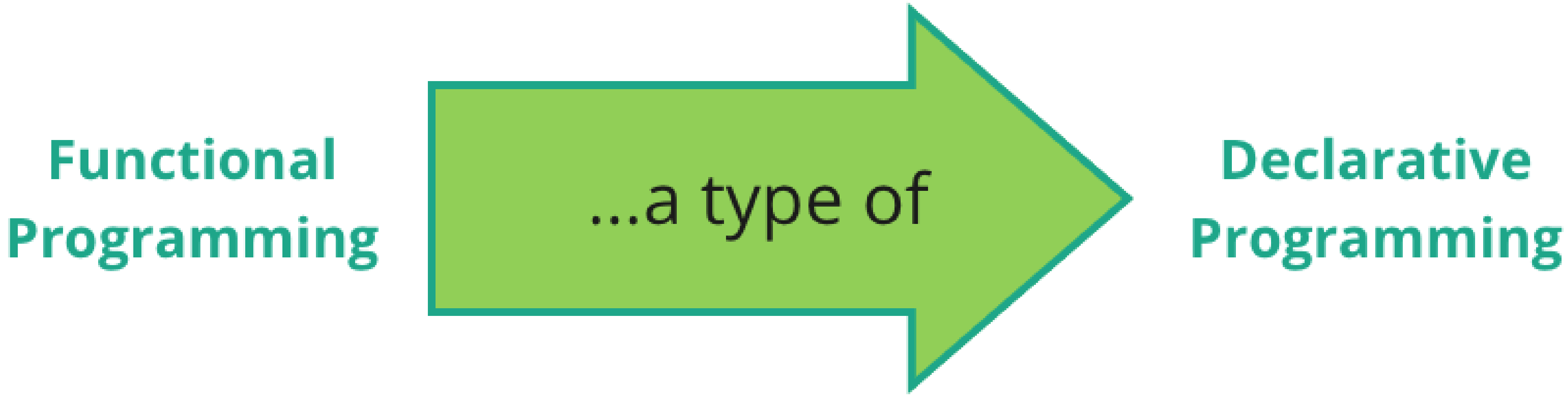
- Easier to read and debug pure functions
- Easier to test pure functions
- Fewer unexpected consequences in the code
- Pure functions are highly reusable from project to project
- Can run different functions in parallel to make code faster

CONS

- Tricky to get used to thinking in this paradigm, can feel limiting: "side effects" (writing to files, etc.) are most of what we *want* to do in programming
- Fewer experts, tools, frameworks exist for functional programming
- Steeper learning curve and fewer educational resources
- Larger memory usage limits applications

Functional programming and declarative programming

- Functional programming is a type of declarative programming
- Declarative programming: tell the computer *what* to do, not *how* to do it
- Functional programming is just *one type* of declarative programming
- Programmer tells the computer what functions to execute, not the exact steps to follow



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Functional programming in action

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Functional programming in action

- Three examples of pure functions
- Key difference between a *pure* function and a general Python function: *no side effects*
- Pure functions can call other pure functions and remain pure

Example 1 - Writing a pure function

```python
def square_list(input_list):
    new_list = []
    for item in input_list:
        new_item = item ** 2
        new_list.append(new_item)
    return new_list
```

- First create a new, empty list
- Go through each item in the input list
  - Square it
  - Append it to new list
- Return new list

Example 2 - Correcting an "impure" function

```python
sample_mean = 10
scale_factor = 2

def scale_list(input_list):
    new_list = []
    for item in input_list:
        new_item = (item - sample_mean) / scale_factor
        new_list.append(new_item)
    return new_list
```

- Depends on variables outside of the function body
- Not a pure function

Example 2 - "Impure" function corrected

```
def scale_list(input_list, sample_mean, scale_factor):
    new_list = []
    for item in input_list:
        new_item = (item - sample_mean) / scale_factor
        new_list.append(new_item)
    return new_list
```

- Variables `sample_mean` and `scale_factor` have become input parameters for the function
- Function is now "pure"

Example 3 - Combining pure functions

```python
def scale_value(value, sample_mean, scale_factor):
    scaled_value = (value - sample_mean) / scale_factor
    return scaled_value

def scale_list(input_list, sample_mean, scale_factor):
    new_list = []
    for item in input_list:
        new_item = scale_value(item, sample_mean, scale_factor)
        new_list.append(new_item)
    return new_list
```

Let's practice!

Recursion in Functional Programming

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What is recursion?

- *Recursive function*: a function that calls itself
- Must contain a termination condition, or base case
- Also contains the recursive call to itself with modified input

```python
def my_recursive_function(input_value):
    # base case
    if base_case_condition:
        return base_case_output_value
    # recursive call
    else:
        return my_recursive_function(modified_input_value) + some_modification
```

Why use recursion?

- Some problems are more straightforward when defined recursively
- Fibonacci numbers:
  - 0, 1, ...
  - 0, 1, 1, ...
  - 0, 1, 1, 2, ...
  - 0, 1, 1, 2, 3, ...

Some more examples of recursion

- Searching through a file system

Some more examples of recursion

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- Certain sort algorithms, such as Merge Sort

Some more examples of recursion

- Searching through a file system
- Certain sort algorithms, such as Merge Sort
- Various data structures are defined recursively

Recursion versus iteration

- Every recursive function can also be written iteratively
- Iterative function uses a loop rather than a recursive call

```python
def iterative_factorial(n):
    result = 1
    for i in range(1, n + 1):
        result = result * i
    return result
```

Let's practice!