Pattern Matching in Python
Learning why Python and patterns are a perfect match

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Hello!

I am Daniel Moisset

I co-authored the Pattern Matching PEP “trilogy” (PEP 634-636)

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It's out!

Pattern Matching comes with the latest Python 3.10b4 (since alpha 6)

Final 3.10 is planned for October 2021
You’re in a maze of twisty little objects, all alike.
The problem

Working with the “shape” of an object
What is the “shape” of an object?

- Type
- Length (of a sequence)
- Present keys (of a mapping)
- Present attributes (of an instance)
- Exact value

And we can combine and nest these...
PATTERN MATCHING

IS THIS A BOOLEAN EXPRESSION?
**Insight:** you’re checking the shape of your object to extract data from it!

<table>
<thead>
<tr>
<th>Condition</th>
<th>Data extraction</th>
</tr>
</thead>
<tbody>
<tr>
<td><code>isinstance(x, Duck)</code></td>
<td><code>foo(x.quack())</code></td>
</tr>
<tr>
<td><code>len(x) &gt; 2</code></td>
<td><code>foo(x[0], x[1])</code></td>
</tr>
<tr>
<td>&quot;key&quot; in x</td>
<td><code>foo(x[&quot;key&quot;])</code></td>
</tr>
<tr>
<td><code>hasattr(x, &quot;beak&quot;)</code></td>
<td><code>foo(x.beak)</code></td>
</tr>
</tbody>
</table>
Patterns
Describing shape+extraction
We need some syntax to decompose an object and assign into variables...

...wait, we already have something like that:

```python
a, *b, c = [1, 3, 5, 7, 9]
```

Let’s crank this idea up to 11!
Object decomposition mimics object creation:

```
print([a, *b, c])
[1, 3, 5, 7, 9]
```
Can the *pattern* generate the *subject*?

<table>
<thead>
<tr>
<th>Pattern</th>
<th>Subject</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>x</td>
<td>True</td>
</tr>
<tr>
<td>x</td>
<td>[1, 2, 3]</td>
</tr>
<tr>
<td>[x, y]</td>
<td>[1, 2, 3]</td>
</tr>
<tr>
<td>[x, y]</td>
<td>[&quot;foo&quot;, 42]</td>
</tr>
<tr>
<td>int(x)</td>
<td>3.0</td>
</tr>
</tbody>
</table>
Some simple patterns:

<table>
<thead>
<tr>
<th>Pattern</th>
<th>Matches if</th>
<th>Extracts</th>
</tr>
</thead>
<tbody>
<tr>
<td>123</td>
<td>obj == 123</td>
<td>-</td>
</tr>
<tr>
<td>True</td>
<td>obj \is\ True</td>
<td>-</td>
</tr>
<tr>
<td>os.SEEK_END</td>
<td>obj == os.SEEK_END</td>
<td>-</td>
</tr>
<tr>
<td>_x_</td>
<td>always!</td>
<td>_x = obj _</td>
</tr>
<tr>
<td>_</td>
<td>always!</td>
<td>-</td>
</tr>
<tr>
<td>Duck()</td>
<td>\isinstance(obj, Duck)</td>
<td>-</td>
</tr>
</tbody>
</table>
### Some composite patterns:

<table>
<thead>
<tr>
<th>Pattern</th>
<th>Matches if</th>
<th>Extracts</th>
</tr>
</thead>
<tbody>
<tr>
<td>(123, a)</td>
<td><code>obj</code> is a sequence</td>
<td><code>a = obj[1]</code></td>
</tr>
<tr>
<td></td>
<td><code>len(obj) == 2</code></td>
<td></td>
</tr>
<tr>
<td></td>
<td><code>obj[0] == 123</code></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>[int(), *mid, int()]</td>
<td><code>obj</code> is a sequence</td>
<td><code>mid = obj[1:-1]</code></td>
</tr>
<tr>
<td></td>
<td><code>len(obj) &gt;= 2</code></td>
<td></td>
</tr>
<tr>
<td></td>
<td><code>isinstance(obj[0], int)</code></td>
<td></td>
</tr>
<tr>
<td></td>
<td><code>isinstance(obj[-1], int)</code></td>
<td></td>
</tr>
<tr>
<td>{“name”: n, “age”: a}</td>
<td><code>obj</code> is a mapping</td>
<td><code>n = obj[“name”]</code></td>
</tr>
<tr>
<td></td>
<td>“name” in obj</td>
<td><code>a = obj[“age”]</code></td>
</tr>
<tr>
<td></td>
<td>“age” in obj</td>
<td></td>
</tr>
</tbody>
</table>
### Extra syntax: alternatives and `as`

<table>
<thead>
<tr>
<th>Pattern</th>
<th>Matches if</th>
<th>Extracts</th>
</tr>
</thead>
<tbody>
<tr>
<td>`200</td>
<td>404</td>
<td>500`</td>
</tr>
<tr>
<td>`[bool()</td>
<td>&quot;yes&quot;</td>
<td>&quot;no&quot; as flag, *_]`</td>
</tr>
<tr>
<td>`[x]</td>
<td>{&quot;value&quot;: x}</td>
<td>x`</td>
</tr>
</tbody>
</table>
### Class patterns

<table>
<thead>
<tr>
<th>Pattern</th>
<th>Matches if</th>
<th>Extracts</th>
</tr>
</thead>
</table>
| Duck(color="green") | `isinstance(obj, Duck)`  
  `hasattr(obj, "color")`  
  `obj.color == "green"` | - |
| Duck(color="green", age=a) | `isinstance(obj, Duck)`  
  `hasattr(obj, "color")`  
  `obj.color == "green"`  
  `hasattr(obj, "age")` | `a = obj.age` |
| Duck(mom=Duck(age=a)) | `isinstance(obj, Duck)`  
  `hasattr(obj, "mom")`  
  `isinstance(obj.mom, Duck)`  
  `hasattr(obj.mom, "age")` | `a = obj.mom.age` |
Putting it all together

The `match/case` statement
Overall syntax

```python
match <subject>:
    case <pattern 1>:
        <code block 1>
    case <pattern 2> if <guard>:
        <code block 2>
    case <pattern 3>:
        <code block 3>
```
Let’s write a “slicer”

Usage: `slicer(seq, [start], stop, [step])`

- `slicer(seq, stop)` → `seq[:stop]`
- `slicer(seq, start, stop)` → `seq[start:stop]`
- `slicer(seq, start, stop, step)` → `seq[start:stop:step]`

Ok, let’s implement:

```python
def slicer(seq, start=0, stop, step=1):
    Hmm... **SyntaxError**: non-default argument follows default argument
```
Pattern match the arguments!

def slicer(seq, *args):
    match args:
        case [stop]: return seq[:stop]
        case [start, stop]: return seq[start:stop]
        case [start, stop, step]: return seq[start:stop:step]
        case _: raise TypeError("invalid arguments")

Let's look at the spec again:
slicer(seq, stop) → seq[:stop]
slicer(seq, start, stop) → seq[start:stop]
slicer(seq, start, stop, step) → seq[start:stop:step]

As Bruce Eckel said: “Python is executable pseudocode”
FizzBuzz

for i in range(1, 101):
    match (i % 3 == 0), (i % 5 == 0):
        case True, True: print("Fizzbuzz")
        case True, _: print("Fizz")
        case _, True: print("Buzz")
        case _: print(i)
Matching on API calls

```python
resp = get_user_info(uuid).json
match resp:
    case {"error": msg}:
        raise APIError(msg)
    case {"user": {"name": n, "dob": d}} if is_birthday(d):
        render(f"Happy Birthday {n}! 🥳")
    case {"user": {"name": n}}:
        render(f"Welcome {n}!")
    case _:
        raise APIError("Unexpected get_user_info response")
```
**A thermonuclear “switch” statement**

```python
def get_user_info(uuid):
    # Implementation

case = get_user_info(uuid).status
match case:
    case 200:
        process_response(case.json)
    case 403:
        raise InvalidUser
    case 301:
        process_redirect(case.location)
    case code if 500 <= code <= 599:
        raise ServerError
    case _:
        raise InvalidStatus
```
Other use cases

- Simple parsers
  - See PEP-636 for an example
- Traverse recursive structures (trees!)
  - Example:
    github.com/dmoisset/patma/blob/rbtree/examples/rbtree.py
The pattern matching paradigm
Pattern matching as a decomposition approach
An alternative to method dispatch

```python
def area(s: Shape):
    match s:
        case Rectangle(w, h): return w * h
        case Square(side): return side ** 2
        case Circle(r): return math.pi * (r ** 2)
        case _: raise InvalidShape

# versus
class Circle(Shape):
    def area(self):
        return self.radius ** 2
```

26
Pattern matching vs. OOP

- PM comes from functional programming
- “Dumb values and smart functions”
- Comparable to method dispatch
  - Emphasis on adding verbs vs. nouns
- Comparable to visitor pattern
  - But straightforward syntax
  - Additional power
Pattern matching vs. switch statement

- Checking is sequential! (a compiler *could* optimise)
- Switch is usually based on literals
- Match can use constant values, but be careful with semantics ("MY_CONST" pattern vs. "mod.MY_CONST")
Further Reading

- PEP-636: The tutorial
- PEP-635: Motivational text
- PEP-634: The spec
- [github.com/gvanrossum/patma/](https://github.com/gvanrossum/patma/): Some code examples (possibly outdated)
Credits

Special thanks to all the people who made and released these awesome resources for free:

- Presentation template by [SlidesCarnival](#)
- Other original images and photographs used with permission from their creators.
Thanks!

You can find me at @dmoisset and dfmoisset@gmail.com
Thank you!

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Questions?

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