Programming Principles in Python (CSCI 503/490)

OS Integration

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Debugging

- print statements
- logging library
- pdb
- Extensions for IDEs (e.g. PyCharm)
- JupyterLab Debugger Support
Print Statements

• Just print the values or other information about identifiers:

```python
def my_function(a, b):
    print(a, b)
    print(b - a == 0)
    return a + b
```

• Note that we need to remember what is being printed

• Can add this to print call, or use f-strings with trailing = which causes the name and value of the variable to be printed

```python
def my_function(a, b):
    print(f"{a=} {b=} {b - a == 0}")
    return a + b
```
Logging Library

- Allows different levels of output (e.g. DEBUG, INFO, WARNING, ERROR, CRITICAL)
- Can output to a file as well as stdout/stderr
- Can configure to suppress certain levels or filter messages

```python
import logging
logger = logging.Logger('my-logger')
logger.setLevel(logging.DEBUG)
def my_function(a, b):
    logger.debug(f"{a=} {b=} {b-a == 0}"")
    return a + b
my_function(3, 5)
```
Python Debugger (pdb)

- Debuggers offer the ability to inspect and interact with code as it is running
  - Post-mortem inspection (%debug, python -m pdb)
  - Breakpoints (just call breakpoint())

- pdb is standard Python, also an ipdb variant for IPython/notebooks
  - p [print expressions]: Print expressions, comma separated
  - n [step over]: continue until next line in current function
  - s [step into]: stop at next line of code (same function or one being called)
  - c [continue]: continue execution until next breakpoint
JupyterLab Debugger
JupyterLab Debugger

![JupyterLab Debugging Interface]

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Testing

• If statements
• Assert statements
• Unit Testing
• Integration Testing
Testing via Print/If Statements

- Can make sure that types or values satisfy expectations
- if not isinstance(a, str):
  raise Exception("a is not a string")
- if 3 < a <= 7:
  raise Exception("a should not be in (3,7]")
- These may not be something we need to always check during runtime
Assertions

• Shortcut for the manual if statements
• Have python throw an exception if a particular condition is not met
• `assert` is a keyword, part of a statement, not a function
• `assert a == 1, "a is not 1"`
• Raises `AssertionError` if the condition is not met, otherwise continues
• Can be caught in an except clause or made to crash the code
• Problem: first failure ends error checks
Unit Tests

• "Testing shows the presence, not the absence of bugs", E. Dijkstra
• Want to test many parts of the code, write functions
• Try to cover different functions that may or may not be called
• unittest, nose2, pytest, doctest
• import unittest

```python
class TestOperators(unittest.TestCase):
    def test_add(self):
        self.assertEqual(add(3, 4), 7)

    def test_add_op(self):
        self.assertEqual(operator.add(3, 4), 7)

unittest.main(argv=[''], exit=False)
```
unittest Options

• Run only certain tests
  - argv=[''] # run default set of tests
  - argv=['', 'TestLists'] # run all test* methods in TestLists
  - argv=['', 'TestAdd.test_add'] # run test_add in TestAdd

• Show more detailed output
  - By default, one character per test plus listing at end
    • F.
    • . indicates success, F indicates failed, E indicates error
  - verbosity=2
    • test_add (__main__.TestAdd) ... FAIL
    test_add_op (__main__.TestAdd) ... ok
Startup and Cleanup for Tests

• **setUp**: instantiate particular objects, read data, etc.
• **tearDown**: get rid of unnecessary objects
• Example: set up a GUI widget that will be tested
  
  ```python
  def setUp(self):
      self.widget = Widget(some_params)
  
  def tearDown(self):
      self.widget.dispose()
  ```

• Also functions for setting up classes and modules
Mock Testing

• Sometimes we don't want to actually execute all of the code that may be triggered by a particular test
• Examples: code that posts to Twitter, code that deletes files
• We can mock this behavior by substituting the actual methods with mockers
• Can even simulate side effects like having the function being mocked raise an exception signifying the network is done
Mock Examples

• Can check whether/how many times the mocked function was called

```python
from unittest.mock import MagicMock
thing = ProductionClass()
thing.method = MagicMock(return_value=3)
thing.method(3, 4, 5, key='value')
thing.method.assert_called_with(3, 4, 5, key='value')
```

• from unittest.mock import patch
  with patch.object(ProductionClass, 'method',
                  return_value=None) as mock_method:
    thing = ProductionClass()
    thing.method(1, 2, 3)
    mock_method.assert_called_once_with(1, 2, 3)
Assignment 6

• Due today
• Object-oriented Programming
• Track University Enrollment
• Methods for checking conflicts (e.g. disallow student to have overlapping courses, take too many credits)
• [503] Methods for changing course time (check the new time works for everyone)
• Sample code is meant to be run in different cells!
Test 2

• Thursday, November 4
• In-person, PM 153, 12:30-1:45pm
• Covers material from the beginning of course, emphasizing material since Test 1
• Similar Format to Test 1
Integration with the Operating System

• For now, focus on the filesystem
  - Listing & Traversing Directories
  - Creating Directories
  - Matching Files
  - Copying, Moving, Removing Files/Directories

• Using Material by Vuyisile Ndlovu:
Modules

- In general, cross-platform! (Linux, Mac, Windows)
- **os**: translations of operating system commands
- **shutil**: better support for file and directory management
- **fnmatch, glob**: match filenames, paths
- **os.path**: path manipulations
- **pathlib**: object-oriented approach to path manipulations, also includes some support for matching paths
Directory Listing

- Old approach: `os.listdir`

- New approach: `os.scandir`
  - Uses iterators, object-based, faster (fewer stat calls), returns `DirEntry`
  - with `os.scandir('my_directory/')` as `entries`:
    ```python
    for entry in entries:
        print(entry.name)
    ```

- Pathlib approach:
  - from `pathlib import Path`
  ```python
  path = Path('my_directory/')
  for entry in path.iterdir():
      print(entry.name)
  ```
Listing Files in a Directory

- Difference between file and directory
- `isfile/is_file` methods:
  - `os.path.isfile`
  - `DirEntry.is_file`
  - `Path.is_file`
- Test while iterating through
  ```python
  from pathlib import Path
  basepath = Path('my_directory/')
  files_in_basepath = basepath.iterdir()
  for item in files_in_basepath:
      if item.is_file():
          print(item.name)
  ```

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Listing Subdirectories

- Use isdir/is_dir instead

  ```python
  from pathlib import Path
  basepath = Path('my_directory/')
  files_in_basepath = basepath.iterdir()
  for item in files_in_basepath:
    if item.is_dir():
      print(item.name)
  ```
File Attributes

- Getting information about a file is "stat"-ing it (from the system call name)
- Names are similarly a bit esoteric, use documentation
- `os.stat` or use `.stat` methods on `DirEntry/Path`
- Modification time:

```python
from pathlib import Path

current_dir = Path('my_directory')
for path in current_dir.iterdir():
    info = path.stat()
    print(info.st_mtime)
```
- Also can check existence: `path.exists()`
Making Directories

- Modify the filesystem
- Know where you **currently are** first
  - `os.getcwd()` or `Path.cwd()`: current working directory
- `os.mkdir`: single subdirectory
- `os.makedirs`: multiple subdirectories
- `pathlib.Path.mkdir`: single or multiple directories (with `parents=True`)
- Can raise exceptions (e.g. file already exists)
- `from pathlib import Path
  p = Path('example_directory/')
  p.mkdir()`
Filename Pattern Matching

- `string.endswith/startswith`: no wildcards
- `fnmatch`: adds * and ? wildcards to use when matching (not just like regex!)
- `glob.glob`: treats filenames starting with . as special
  - can do recursive matchings (e.g. in subdirectories) using **
- `pathlib.Path.glob`: object-oriented version of glob
- `from pathlib import Path
  p = Path('.')
  for name in p.glob('*.p*'):
    print(name)"
Pathname Manipulation

• `os.path.split` returns tuple (dirname, basename)
  - can use `os.path.dirname/basename` to get these only
  - `os.path.split('/path/to/file.txt')` # ('/path/to', 'file.txt')

• `os.path.join`: inverse of split

• `os.path.splitext`: split filename and extension

• `pathlib.Path` has OOP versions:
  - `.parent/.name == dirname/basename`
  - `.stem/.suffix ~ splitext, also suffixes`
  - `/ operator (also joinpath ~ join)`
Traversing Directories and Processing Files

- `os.walk`
- ```
  for dirpath, dirnames, files in os.walk('.'):  
      print(f'Found directory: {dirpath}')  
      for file_name in files:  
          print(file_name)
```  
- Returns three values on loop iteration:
  1. The name of the current directory
  2. A list of subdirectories in the current directory
  3. A list of files in the current directory
- `topdown` and `followlinks` arguments
- `pathlib` algorithms exist but DIY
Temporary Files and Directories

- tempfile knows system directories for storing temporary files
- deletes the file when it is closed
- from tempfile import TemporaryFile
  
  ```python
  with TemporaryFile('w+t') as fp:
      fp.write('Hello universe!')
      fp.seek(0)
      fp.read()
  # File is now closed and removed
  ```
- Can also use in with statement (context manager)
- Can also create temporary directories
Deleting Files and Directories

- Files: `os.remove` or `os.unlink`, or `pathlib.Path.unlink`
- from `pathlib import Path`
  Path('home/data.txt').unlink()

- Directories: `rmdir` or `shutil.rmtree`
  - `rmdir` only works if the directory is empty
  - **Careful**: this deletes the entire directory (and everything inside it)
    - `shutil.rmtree('my_documents/bad_dir')`
Copying Files & Directories

- **shutil.copy**: copy file to specified directory
  - `shutil.copy('path/to/file.txt', 'path/to/dest_dir')`

- **shutil.copy2** preserves metadata, same syntax

- **Copy entire tree**: `shutil.copytree('data_1', 'data1_backup')`
Moving and Renaming Files/Directories

- Moving files or directories:
  - `shutil.move('dir_1/', 'backup/')`

- Renaming files or directories:
  - `os.rename`
  - `pathlib.Path.rename`
  - `data_file = Path('data_01.txt')`
    `data_file.rename('data.txt')`
Archives

- zipfile: module to deal with zip files
- tarfile: module to deal with tar files, can compress (tar.gz)
- Easier: shutil.make_archive
  - Specify base name, format, and root directory to archive
  - shutil.make_archive('data/backup', 'tar', 'data/')
- To extract, use shutil.unpack_archive