Configuring programs and using APIs

Data Sciences Institute
University of Toronto

Simeon Wong

Introductions

Meet your instructor

Simeon Wong

4th year PhD @ Institute of Biomedical Engineering

Research Analyst @ Hospital for Sick Children

- I read minds!
  (of children with epilepsy using implanted electrodes)
- MRI, CT image processing
- EEG, MEG signals processing
- Neuromodulation platforms for research

Introductions

Meet your TA

Tong Su

- 4th year undergrad @ University of Toronto
- Computer Science Specialist and Statistics Major
- Full-stack developer at Northbridge (Co-op)
- Research Interest: Computer Vision, Natural Language Processing, and Machine Learning

Asking questions

- Zoom chat during class
  - Feel free to post and answer questions at any time
  - I will pause for questions occasionally, and review questions from the chat
- Pre- / Post-class office hours with Tong
- Email
  - simeonm.wong@mail.utoronto.ca
  - tong.su@mail.utoronto.ca

Daily scrum

Write in the chat:

1. How you'll use one thing you've learned so far
2. One thing you're struggling with / wish the course addressed
3. What you're looking forward to in this course

Course overview

1. Configuration files & Environment variables
2. Using and writing Application Programming Interfaces (APIs)
3. Handling errors
4. Testing software
5. Building Python packages
6. Working in software teams using GitHub features

Course overview

1. **Configuration files & Environment variables**
2. **Using and writing Application Programming Interfaces (APIs)**
3. Handling errors
4. Testing software
5. Building Python packages
6. Working in software teams using GitHub features

Assessments

- Outcomes-based learning
  - > 75% of course outcomes
- Assessed with both in-class exercises and summative project
- Summative project:
  - The next 4 classes build on each other
  - We will work on the summative project step-by-step through each class

Today’s learning outcomes

- I can interpret and write simple YAML files
- I can load YAML files into Python
- I can read command line arguments from Python
- Given documentation, I can use a Python or HTTP API

Why configure?

- Programs are only useful if they can be **controlled**.
- Work inside programs is **reproducible** only if controls are **explicit** (documented and understandable) and **shareable**.
- Programs may need to work differently in different contexts:
  - Operating systems
  - Data directories
  - Localization: language, region settings
  - Analytical methods or outputs (e.g. linear vs quadratic regression)

Data sources

- Data that controls how a program functions can come from multiple sources:
  - Context
    - Current operating system
    - System language
  - Files
    - Configuration files or job description files
  - Dynamic sources
    - Network server, etc…

Layers of configurations

1. Default program configuration
2. System-wide configuration
   - General settings that impact all users (and multiple programs)
3. User-specific configuration
   - Personal preferences
4. Job-specific configuration
   - Run-specific information
5. Command-line options
   - Frequently changed, or on-the-fly configuration

Default program configuration

- Sensible defaults included with the program
  - Designed to be generally useful for most people who run the program
  - e.g. matplotlib default colour is blue
- Consider different types of users
- Be careful of unexpected behaviour if left unconfigured
  - e.g. Program that saves data to `financials.xlsx` by default
    - Might unintentionally overwrite users' files
  - Some defaults should not be set to force users to specify

System-wide configuration file

Purpose: To provide default settings applicable to all users of a system.

Impact: Changes affect every user and application on the system.

Modification and Risks: Editing system-wide files requires caution as incorrect settings can impact system stability.

e.g: Modifying a system-wide configuration file in an operating system to change the default network timeout settings. This change will affect all network-related operations for all users, even those using other programs.

User-Specific Configuration

Scope: Settings that apply only to a single user's environment.

Flexibility: Allows personalization without affecting other users.

Storage: Typically stored in user's home directory or specified user profile sections.

e.g: A user creates a configuration file in their document editor to set a default font size and page layout, different from the system-wide defaults.

Job-Specific Configuration

Application: Used for settings that apply to a specific task or project.

Priority: Overrides system and user-specific settings for the job's duration.

Creation and Use: Crafted for individual projects or tasks, often located within the project directory.

e.g: Setting up a configuration file in a data analysis project to specify data sources and output formats unique to that project.

Command-line options

Use: For temporary adjustments or one-off changes.

Flexibility: Allows quick, on-the-fly changes without altering permanent configurations.

Best Practices: Use for frequent or minor changes; avoid for complex configurations.

e.g: Running a file compression tool with command-line options to set a high compression level for a specific large file, overriding the default compression setting.

Layers of configurations

1. Default program configuration
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   - Personal preferences
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Overlay/override system

- The same option is valid in multiple configuration layers
- Options read from more specific layers override settings configured in more general ones

e.g: Plot colours for an analysis program

- Program's default colour is blue (matplotlib default)
- Your organization's brand colour is green (system-wide)
- For this specific analysis, need to use orange (job-specific)

What questions do we have?

Course logistics

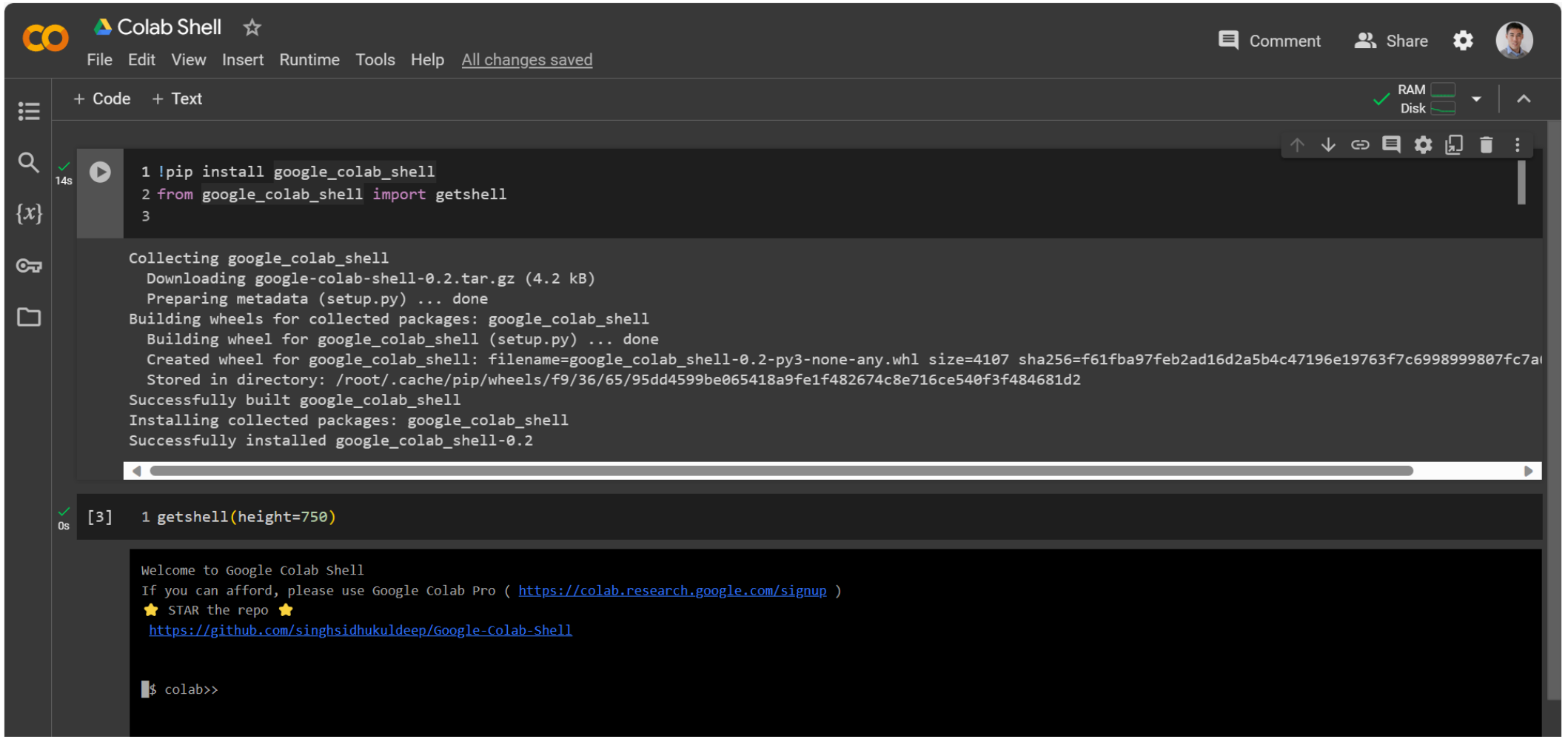
Demo: Google Colab Terminal

- UofT DSI uses Google Colab for Python
- Parts of this course will require using Git and Python from the command line (instead of the notebook interface)

- **If you have a Unix shell, Git, and Python installed locally**: feel free to use that
- **If you are not sure or you do not:** we can access a basic shell on Google Colab

Course logistics

Demo: Google Colab Terminal



Command-line arguments in Python

- The **argparse** library built into Python is used to interpret command-line arguments
- Common types of command-line arguments
  - Positional argument (e.g. `mv oldpath newpath`)
  - Flags (true/false values) (e.g. `ls -l`)
  - Options with values (e.g. `head -n 5`)

$> Interactive live coding

1. Create a Python script in Google Colab (or on your local computer)
2. Make it print “Hello World!”
3. Referring to the **argparse** documentation:
    1. Initialize **argparse**
    2. Write a short description
    3. Add a **positional argument** for greeting target
    4. Add an **option** for number of repeats
    5. Add a **flag** for saying goodbye

What questions do we have?

Configuration file formats

Popular Formats:

- INI – older format for simple, structured data
  - Commonly found in compiled Windows / Linux programs
- JSON – older standard, flexible, can be difficult to type by hand
- YAML – new standard, readable and flexible

Due to its flexibility and readability, especially for complex configurations, YAML is recommended.

Configuring programs

The YAML format

```
key: value

dict:
  key1: value1
  key2: value2

list:
  - value1
  - value2

# comment
```

“YAML is Another Markup Language”

Online tools for browsing YAML:
https://codebeautify.org/yaml-parser-online

$> Interactive live coding

1. Create a YAML file in Google Colab
2. Write Python code to load and consolidate YAML files
3. **Exercise:** Write your own configuration files
   - For an analysis where a dataset is loaded and two columns from the dataset are plotted on the x and y axes in your favourite colour
   - Variables: dataset_url (str), cols_to_plot (dict with x and y str), color (str)
   - Which configuration levels do these variables go into?

What questions do we have?

Lesson overview

Today's overview

1. Configuration files & Environment variables
2. Using and writing Application Programming Interfaces (APIs)

What is an API?

- API stands for Application Programming Interface
- Allows software programs to communicate with each other
- Provides structured way to communicate between applications and devices (expose data and functionality)
- Allows other developers to access and integrate with an application without needing to understand complex implementation details

Application Programming Interfaces

Programs using programs

- You've already used APIs!
- Python APIs: matplotlib, numpy, pandas
- Web APIs: City of Toronto open data API

Public APIs vs Private APIs

- Public vs private refers to access, visibility, and documentation

Public APIs

- Available openly for any developer to use
- Well-documented and robustly coded to account for different (and untrusted) requests and input from the public
- Public Web APIs: Just need to sign up and get an API key to access
- e.g. GitHub, Spotify, YouTube

Public APIs vs Private APIs

Private APIs

- Access is restricted to internal apps or trusted external partners and requires authorization
- May be coded/documented for very specific use cases
- For interacting with internal data and functionality safely
- e.g.: APIs for internal tooling, bank partnerships

Public APIs vs Private APIs

- When writing APIs for public use:
  - Must validate inputs strictly
    - Defend against coding mistakes
    - Defend against malicious users (e.g. access to unauthorized data, system compromise)
  - Must document extensively
- Tradeoff between additional utility and engineering-hours

What questions do we have?

Application Programming Interfaces

The RESTful Web API

- The RESTful Web APIs are a quasi-standard method of performing actions using or exchanging data with web-connected services
  - e.g. Retrieve list of repositories from GitHub
  - e.g. Using GPT-4 to process datasets automatically
  - e.g. Starting and stopping a container hosted on Microsoft Azure
- REST: “Representational State Transfer”
  - Uses HTTP requests: GET, POST, (PUT), (DELETE)
  - Generally, returns data in machine-readable formats like JSON

The RESTful Web API

- Uniform interface
  - Every entity (piece of data) is generally retrieved from the same URI
- Client-server decoupling
  - The web interface is assumed to be the only link between the client and the server
  - Data isn't getting passed through a separate channel (e.g. file on hard drive)
- Statelessness
  - All required information is included in the request
  - Identity is established on every request (usually via a secret token)

Application Programming Interfaces

The RESTful Web API

Client

GitHub API
(https://api.github.com)

GET /user
Authorization Bearer zn4 … 2l3

"Get details about myself.
I am identified by … "

```
{ "login": "octocat", "id": 1,
"node_id": "MDQ6VXNlcjE=",
"avatar_url":
"https://github.com/images/error/oct
ocat_happy.gif", "gravatar_id": "",
"url":
"https://api.github.com/users/octoca
t", "html_url":
"https://github.com/octocat", … }
```

API keys

- Unique string that acts like a password obtained by registering as a developer
  - Usually time-limited (hours to months)
- Identifies the client: Usage tracking and access limits
- API keys are usually sent in the request header
  - e.g. `Authorization: Bearer 2374823842823442`
- Keep your key secret - don't share or expose!
  - Store using secrets manager or protected configuration file (.gitignore is your friend!)

Web API responses

- Consists of an HTTP response code + body
- Response codes:
  - 2xx = success (e.g. 200)
  - 4xx = error with the request (e.g. 404 URI not found, 400 bad request)
  - 5xx = error with the server (e.g. 500 internal server error)
- The body is generally in JSON format (rarely, but sometimes in XML)

What questions do we have?

Making Web API requests in Python

- Use the **`requests`** library to communicate with the API
- Use the **`json`** library to parse JSON responses

- Sometimes companies release Python libraries that make it easier to use their APIs from Python
  - Simplify authentication, request validation, response parsing, etc...

$> Interactive live coding

1. Generate a GitHub Personal Access Token (API key)

   Settings > Developer Settings > Personal access tokens

2. Add token to Colab secrets manager
3. Refer to GitHub API Documentation
4. Use **`requests`** to retrieve own user details from GitHub Web API

Application Programming Interfaces

$> Interactive live coding

```python
import requests
import json
from pprint import pprint

from google.colab import userdata

token = userdata.get('ghtoken')

response = requests.get(url='https://api.github.com/user',
                        headers={'Authorization': 'Bearer ' + token})

# print raw response
print(response.status_code)
print(response.text)

# parse json
response_json = json.loads(response.text)
pprint(response_json)

# print some values
print('Username: ' + response_json['login'])
print('Name: ' + response_json['name'])

```

```
200
{"login":"dtxe","id":7825879,"node_id":"MDQ6VXNlcjc4MjU4Nzk=","avatar_url":"https://avatars.githubusercontent.com/u/7825879?v=4","gravatar
{'avatar_url': 'https://avatars.githubusercontent.com/u/7825879?v=4',
 'bio': 'PhD student in Biomedical Engineering at SickKids and the University '
        'of Toronto.\r\n'
        'Building responsive neuromodulation strategies for children with '
        'epilepsy.',
 'blog': 'https://simeonwong.com',
 'company': 'Hospital for Sick Children',
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 'gravatar_id': '',
 'hireable': None,
 'html_url': 'https://github.com/dtxe',
 'id': 7825879,
 'location': 'Toronto, ON',
 'login': 'dtxe',
 'name': 'Simeon Wong',
```

What questions do we have?

Exercise: Explore the GitHub API

- Using the GitHub API documentation:
  - choose an interesting endpoint that returns data
  - write a Python request to retrieve data from that endpoint
  - *bonus*: visualize or analyze it in some way
- Ideas:
  - List the top 20 most starred repositories using /search/repositories
  - List the top 20 most followed users using /search/users
    - Hint: try using q=stars:>1 or q=followers:>1

What questions do we have?

Homework

- Create a personal GitHub repository for today's work
  - We suggest making it public
  - Otherwise, private with dtxe and Sue-Tong as collaborators
- Commit your Hello World and your GitHub API code
  - Write a suitable commit message
  - Write a simple README.md file
- Push your commit and submit your work here: https://uoft.me/dsi-1-bs-a1

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References

- Research Software Engineering with Python by Damien Irving, Kate Hertweck, Luke Johnston, Joel Ostblom, Charlotte Wickham, and Greg Wilson (https://merely-useful.tech/py-rse/config.html)