Lab Assignment 4: Exploring cyclomatic complexity (MCC) changes in Open-Source Repositories

# INTRODUCTION, SETUP, AND TOOLS

## Introduction

The purpose of this lab is to analyze the impact of code changes (git diff) on McCabe's cyclomatic complexity metric (MCC) in OSS ecosystems like GitHub. we need to analyze cyclomatic complexity values before and after changes in code files. and lastly the impact of source code changes (git diff --histogram) on the well-known McCabe's cyclomatic complexity metric. we used **Pydriller** to extract commit data, **Lizard** to calculate MCC, and **Py2cfg** to generate Control Flow Graphs (CFGs)

## Setup

we need to have Pydriller Lizard Py2cfg Matplotlib

- **Installation:** we need to install **pydriller, Lizard**, **Py2cfg**, and **Matplotlib** on the local machine before starting lab.
- **Python Installation:** We need to have Python 3.10.

## Tools

- **pydriller:** is an open-source Python library that allows you to "drill into" git repositories.
- **Lizard Installation**: used for calculating cyclomatic complexity.
- **Py2cfg Installation**: is used for generating control flow graphs (CFGs) from Python code.
- **Matplotlib:** is a comprehensive library for creating static, animated, and interactive visualizations in Python.

# METHODOLOGY AND EXECUTION WITH RESULT AND ANALYSIS

## Repository Selection:

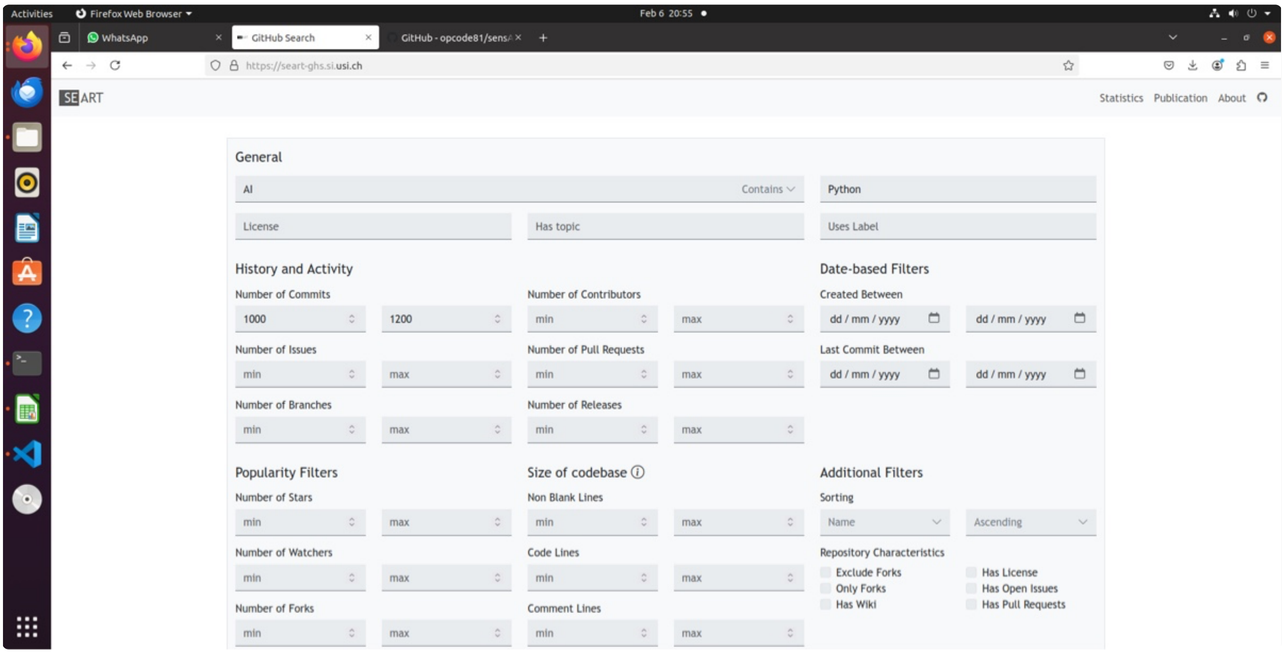
For the analysis I selected the repository sensAI **[2]**. This is an AI-based project that focuses on providing solutions for sensor data analysis, leveraging machine learning techniques for predictive analytics and anomaly detection. It fits the criteria of a medium-to-large scale open-source repository.

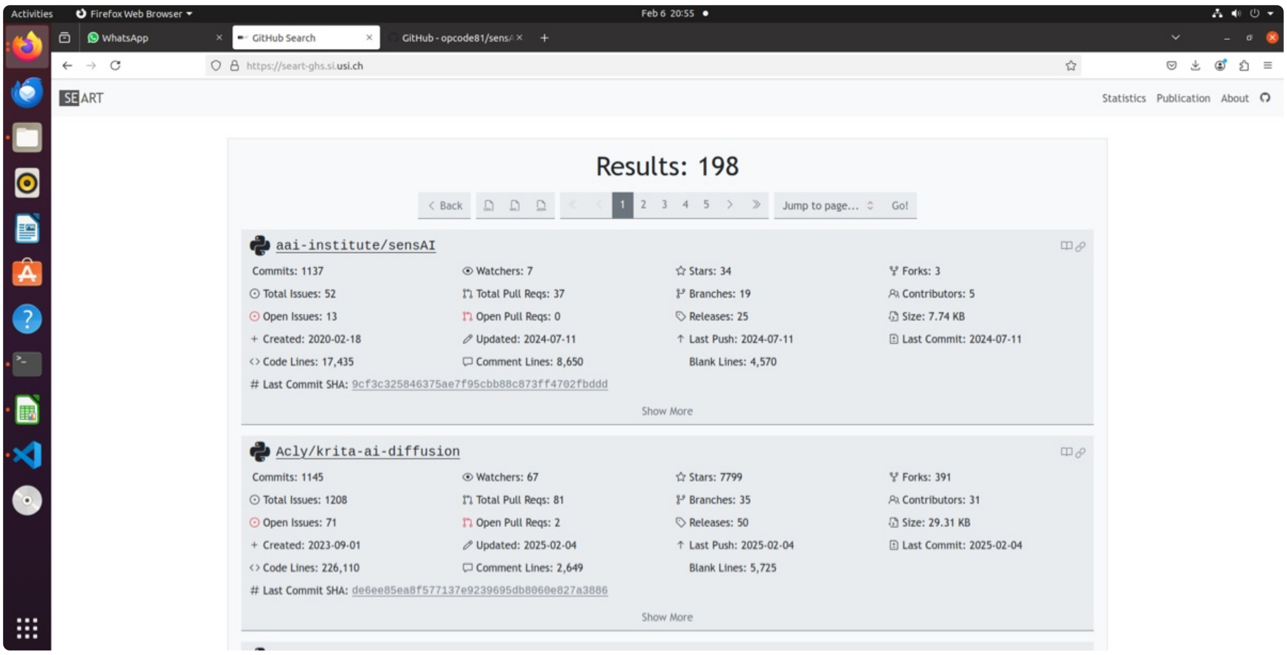
## Define Selection Criteria:

As this aligns with your previous lab, and we like to keep it same criteria for this analysis as well to establish where I use the SEART GitHub Search Engine [3] and established the following **selection criteria**:

- **Search**: In search I added AI so that I get repository which are working either with AI or on AI.
- **Language**: In Language I added python so that I get repository which are working either with python or on python as recommended.
- **Number of Commits**: The repository must have commits between **1000 and 1200**. This will indicates that the repository is actively developed and also not too large to make analysis difficult.

And selected **sensAI** **[2]** repository as first preference. the following image shows the process and output.




## Software Tool Setup:

Download, install, and configure pydriller using command given on **Pydriller** [1]

```
pip install pydriller
pip install py2cfg
```

Every thing is same as in Assignment 3 just added new helper function for and removed extra helper function

**Compare get `old_mcc` and `new_mcc` in Myers' diff and histogram:** This function old cyclomatic complexity from the older `source_code_before` and new cyclomatic complexity colum from the `source_code`

```
def get_cyclomatic_complexity(source_code):
    try:
        analysis = lizard.analyze_file.analyze_source_code("temp.py", source_code)
        return sum(func.cyclomatic_complexity for func in analysis.function_list)
    except Exception as e:
        print(f"Error computing complexity: {e}")
        return None
```

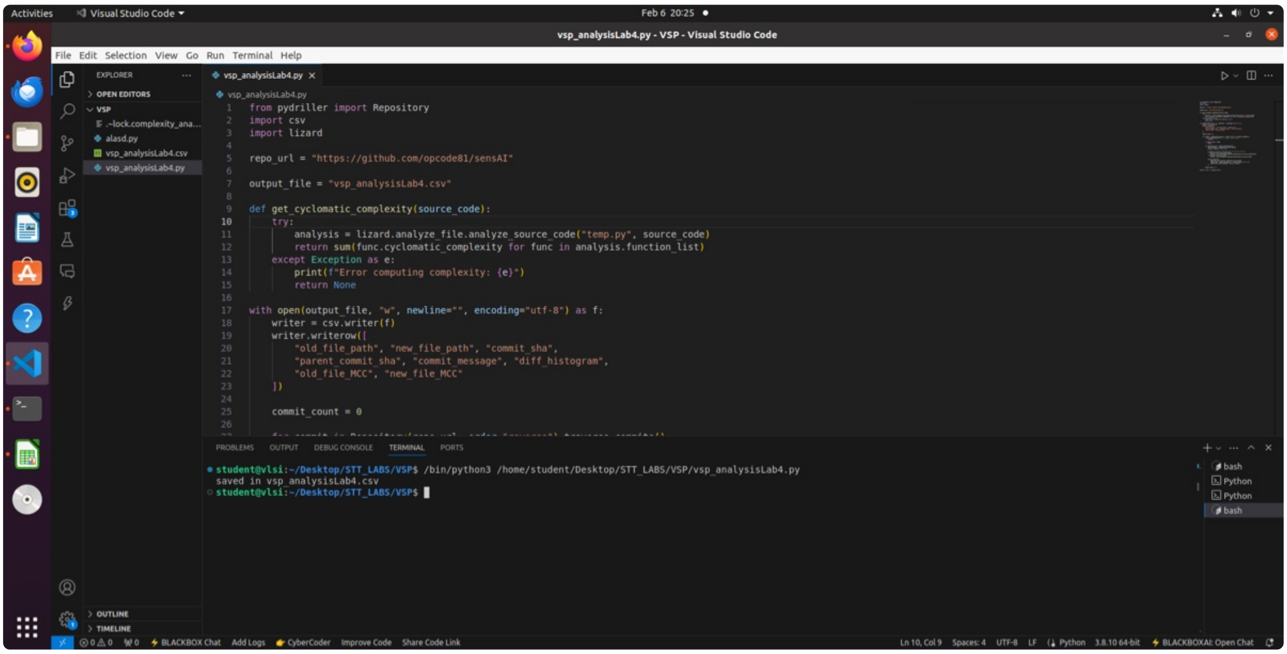
some minute changes in calling commits from **pydriller**

```
for commit in Repository(repo_url, order="reverse").traverse_commits():
        if len(commit.parents) > 1:  # Ignore merge commits
            continue

        if commit_count >= 500:
            break

        for modified_file in commit.modified_files:
            diff_histogram = modified_file.diff_parsed
            old_mcc, new_mcc = None, None

            # Compute cyclomatic complexity for old and new versions
            if modified_file.source_code_before:
                old_mcc = get_cyclomatic_complexity(modified_file.source_code_before)
            if modified_file.source_code:
                new_mcc = get_cyclomatic_complexity(modified_file.source_code)

            writer.writerow([
                modified_file.old_path, modified_file.new_path,
                commit.hash, commit.parents[0] if commit.parents else 'N/A',
                commit.msg, diff_histogram, old_mcc, new_mcc
            ])
```

full code with csv: [https://drive.google.com/file/d/18ogqG9TQcEBoWxwcyi58TIYVWf8w2d7F/view?usp=sharing](https://drive.google.com/file/d/18ogqG9TQcEBoWxwcyi58TIYVWf8w2d7F/view?usp=sharing) following is screenshot after runing this part

After running this Python script, the analysis generates a CSV file ( `vsp_analysisLab4.csv` ) which includes the following columns (similar like past just removed the code that was not been used and added new for adding old_mcc and new_mcc):

- old_file_path: The file path of the original version.
- new_file_path: The file path of the modified version.
- commit_sha: The SHA hash of the commit.
- parent_commit_sha: The SHA hash of the parent commit (if available).
- commit_message: The message describing the commit.
- diff_myers: The diff output generated using the Myers algorithm.
- diff_histogram: The diff output generated using the Histogram algorithm.




## Analyze trends:

**Identify and report the top 3 frequently changed source code files.**

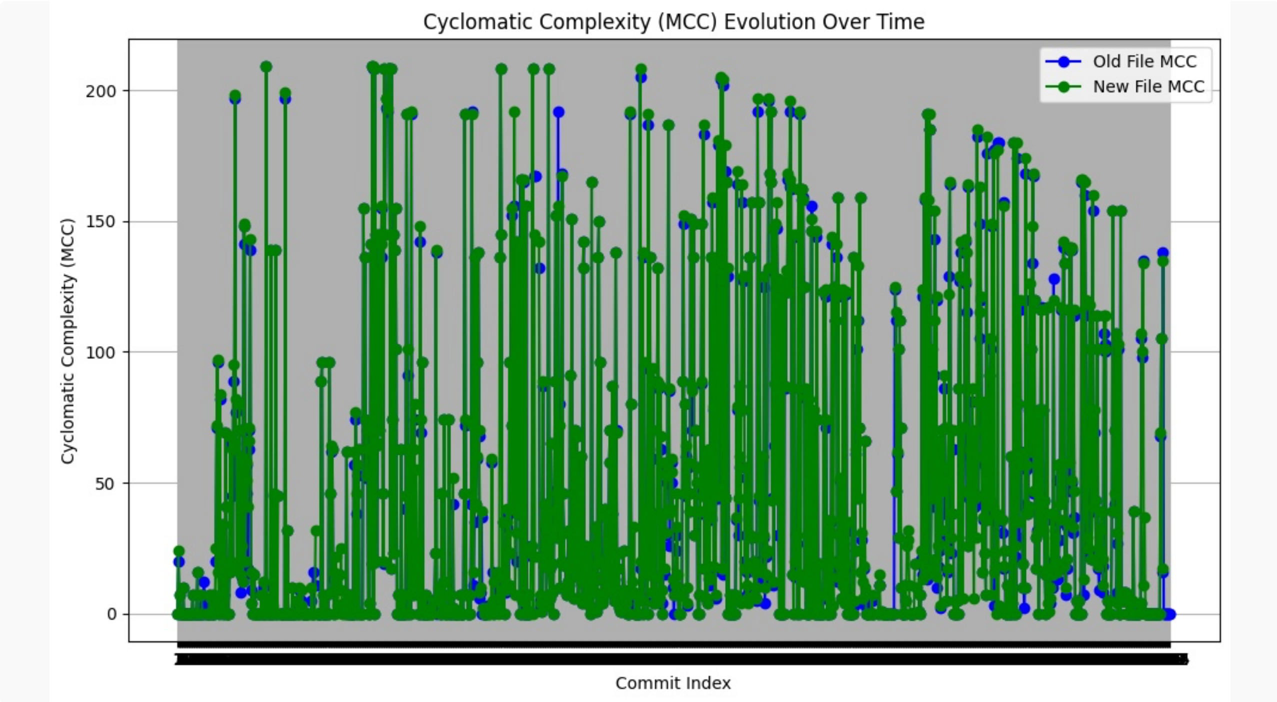
```python
import pandas as pd

df = pd.read_csv('vsp_analysisLab4.csv')

file_changes = pd.concat([df['old_file_path'], df['new_file_path']]).value_counts()

top_3_files = file_changes.head(3)
print(top_3_files)
```

```
setup.py                            96
src/sensai/evaluation/eval_util.py  96
src/sensai/__init__.py              80
Name: count, dtype: int64
```

- **`setup.py` (96 changes)**
  - This file is usually responsible for package configuration and dependency management.
- **`src/sensai/evaluation/eval_util.py` (96 changes)**
  - This file is part of the sensai package contains utility functions for evaluation.
- **`src/sensai/__init__.py` (80 changes)**

- The **init**.py file is used for module initialization.

**Plot the changes of cyclomatic complexity values along the timeline of software evolution.**




Python code used to genrating plotings is in [https://drive.google.com/file/d/1bGZt2waLlg1oHMmMbvh_epBwWcPnpVPW/view?usp=sharing](https://drive.google.com/file/d/1bGZt2waLlg1oHMmMbvh_epBwWcPnpVPW/view?usp=sharing)

The plot suggests that the cyclomatic complexity of this has increased been constant over time.

More fluctuations in MCC indicate growing complexity in the project.

The blue dots (old file MCC) are generally lower than the green dots (new file MCC), suggesting that changes to the code often introduce more complexity.

The vertical green lines indicate that MCC frequently spikes after modifications.

# DISCUSSION AND CONCLUSION

### Discussion:

In this lab, we analyzed how code changes in the **sensAI** repository impacted McCabe's cyclomatic complexity (MCC). I found that changes often led to an **increase in Complexity**, reflecting the natural complexity introduced when adding new features or logic. The plot revealed that the **new MCC values** (green dots) were generally higher than the old ones (blue dots), indicating that changes added more decision points to the code.

We also identified key files with frequent changes, such as **[setup.py](setup.py)**, **eval_util.py**, and **init.py**, which likely contributed to these increases.

### Conclusion:

This analysis shows that software modifications tend to increase cyclomatic complexity, which may suggest growing code complexity and potential challenges in maintaining the codebase. Tracking MCC over time helps developers assess code evolution and identify areas needing attention to prevent excessive complexity. Future work could explore additional quality metrics to better understand the relationship between code changes and software health.

## APPENDIX

I would like to express my sincere gratitude to my course instructor, Prof. **Shouvick Mondal**, for his invaluable guidance and support throughout this lab. I also appreciate the assistance from All TAs, whose help with me with troubleshooting.

Additionally, I am grateful for the resources provided, including Which I have sited down which helped me resolve issues efficiently. Finally, I'd like to thank my peers for contributing to a collaborative and supportive learning environment.

## CITATION

*[1] ClassroomCode / py2cfg · GitLab*. (n.d.). GitLab. https://gitlab.com/classroomcode/py2cfg

*[2]* Ishepard. (n.d.). *GitHub - ishepard/pydriller: Python Framework to analyse Git repositories*. GitHub. https://github.com/ishepard/pydriller

*[3]* Terryyin. (n.d.). *GitHub - terryyin/lizard: A simple code complexity analyser without caring about the C/C++ header files or Java imports, supports most of the popular languages*. GitHub. https://github.com/terryyin/lizard

*[4] Class Slides L3 - https://drive.google.com/file/d/1zGLtjHGxbytlzDX8gzOai5CSv3gqzxMU/view*

*[5] Class Slides L4 - https://drive.google.com/file/d/1gFJe5qDeloQDIEyRdLswWEr_n9xNaH7r/view*

*[6] Lab Manual - https://drive.google.com/file/d/1PuUM5NwfCPJOvC1g6cv5131QVOkxUDtg/view*

*[7] SEART (Github Repo Search)- https://seart-ghs.si.usi.ch/*