Work Summary and Documentation

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For: Dr. Cliff Shaffer and Rifat Mansur| Course: CS 4994 Undergraduate Research

# Overview

This documentation is meant to serve as a reference for the work that I, Jonathan Reynosa, did throughout the Spring 2023 semester for the course CS 4994 at Virginia Tech. My work was overlooked by Dr. Cliff Shaffer, and I worked very closely with Ph.D. candidate Rifat Mansur. Over the course of the semester, I worked on a total of three (3) scripts and their documentation is outlined below. My work started with familiarizing myself with the data and observations I would be working with by reading the following research papers:

* [DevEventTracker: Tracking Development Events to Assess Incremental Development and Procrastination](https://dl.acm.org/doi/pdf/10.1145/3059009.3059050)
* [Quantifying Incremental Development Practices and Their Relationship to Procrastination](https://dl.acm.org/doi/pdf/10.1145/3105726.3106180)
* [Exploring the Bug Investigation Techniques of Intermediate Student Programmers](https://dl.acm.org/doi/pdf/10.1145/3428029.3428040)
* [Fast and accurate incremental feedback for students’ software tests using selective mutation analysis](https://www.sciencedirect.com/science/article/pii/S0164121221000029)

From these research papers, I was given a different perspective on programming feedback and Web-CAT, Virginia Tech’s web-based tool for automated testing. Further, I was exposed to sensor data from DevEventTracker as well as what observations are drawn from said data and I was introduced to the idea of mutation testing. Following this I was given my first task which was to update mutation testing scripts to fit our use case from an existing [GitHub repository](https://github.com/ayaankazerouni/mutation-testing). Upon completion, I was then tasked with modifying a script written in JavaScript to fit the sensor data which would be used to clone student GitHub repositories for further analysis. Lastly, my final task of the semester was to make use of existing scripts to process raw sensor data and map the data to student UUIDs and project UUIDs, and this was outputted in the format of a CSV file. My work is further summarized and documented below.

# Mutation Testing

## Summary

I was given the following GitHub repository as a starting point for this task: [GitHub Link]. I had to make several changes to the python scripts in order to meet the following three (3) requirements:

1. Run PIT mutation analysis on provided final student submission data.
   1. Example data, screenshot or link
2. Use only the following mutators for our mutation analysis:
   1. AOD1
   2. AOD2
   3. REMOVE\_CONDITIONALS\_EQUAL\_ELSE
   4. REMOVE\_CONDITIONALS\_EQUAL\_IF
   5. REMOVE\_CONDITIONALS\_ORDER\_ELSE
   6. REMOVE\_CONDITIONALS\_ORDER\_IF
3. Produce a final CSV file similar to this [CSV Link].

I forked the provided GitHub repository and modified the following nine (9) files:

1 & 2) Documentation.docx and README.md

* + Documentation.docx is this document and I updated the README.md to reflect my work and credit the original repository.

3 – 5) pit/Dockerfile, pit/run-docker.sh, and pit/automated-data-collection.sh

* + Lorem

6) pit/clone-projects.py

* + Lorem

7) pit/pit-runner.py

* + Lorem

8) pit/utils.py

* + Lorem

9) write\_tasks.py.

* + Lorem

Links to consider:

<https://github.com/ayaankazerouni/mutation-testing>

<https://pitest.org/quickstart/mutators/>

Final Sub Data - <https://drive.google.com/drive/folders/1FHup2dqrOcy5Z52oFeemHZaG5YexEnNb?usp=sharing>

Output CSV Example – <https://drive.google.com/file/d/1g9Eh4_38DBvAafBuxdV3qQ0q9aCoOzBC/view?usp=share_link>

Misc to talk about

Adding submissonNo column

Errors I ran into

## Usage

# Cloning Repositories

## Summary

## Usage

# Sensor Data Mapping

## Summary

## Usage

**2/23 Meeting:**

Working on sudo access on LTI system to get the script to start processing

Have the FA16 data but that data did not make use of mutation testing data

Looking for two kinds of data and both need analysis

* GitHub
* Sensor Data

<https://drive.google.com/drive/u/2/folders/19-g09K9RUKMatS0w5_QhuneMiBdnigtd>

Ri has a script, we need to run script with the new additional CSV from URL above

Uuid is user-id

Project uuid is specific project

Both of these we can use to clone their Git repos

Create a new CSV file with 10 entries, and use this as a temp data

Look to divide the data into batches, manually or in code

Try to do two kinds of analyses

Workload after we introduced Mutation Testing

* Mutation testing requires more data and thus more time
* System runs locally, so there is no need to submit to WebCat to get MT feedback
* Still need to submit for style
* What if they didn’t have the plugin, they would have to submit to WebCat each time
* This is where we use sensor data, how often they run the MT tests
* We can see what the work load is compared to before the plugin

Actual Coverage of the Students

* Execute MT script on <> to get an idea of code coverage
* If there is a difference after MT introduction, we can see an improvement on student testing quality

Looking to write a paper on these, Ri has started writing the paper but timing looks a little tight:

Abstract due 3/17

Final due 3/24

If we don’t get data from Edwards we might have to use data from the past

**Notes:**

Edited pit-runner to run the custom mutations Ri wanted

Need to run pit-runner.py with a task file

Task file can be obtained by using write\_tasks.py

Write\_tasks.py needs a path as an arguments and prints task file results to console, but can also be piped to a file

Error with file so had to change code to specify the encoding of the .ndjson/.json file

Had to download Apache Ant

Fiddled with automated runner but it was a bit confusing, so chose to tailor code to data

Edited outerdir in clone-projects.py

Run w/: python .\pit-runner.py -m custom --log .\tasks.json; After we have the task file created by write\_tasks and after project has been copied using clone-projects.py

Some error w/ AOD2 not being included somewhere? - Ri explained in email

Why do some projects result in .jar and some in .zip - Ri explained in email

Editing clone-projects for the pre-processing to fit out data

Install perl via Anaconda

Switched to Linux environment, have to download Java

Edited utils.py to get final CSV

Meeting w/ Ri: (2/7)

* **Processed:** 
  + 2021\_Summer\_I\_Project1
    - 36 Student Submissions Total
    - 4 Submissions Failed Total
      * Mjiaqi18: Submission #9
      * Marktd19: Submission #15
      * Xuanjie: Submission #9
      * Vishalms: Submission #31
  + 2022\_Spring\_Project1
    - 67 Student Submissions Total
    - 2 Submissions Failed Total
      * Jasonguan0107: Submission #2
      * Wutp20: Submission #12
  + 2022\_Fall\_Sally\_Project2
    - 128 Student Submissions
    - 41 Submissions Failed Total
      * Edmondpm24: Submission #s 1-3 (3)
      * Tejiyer6: Submission #s 18,19,21,23 (4)
      * Nahomk: Submission #s 26-36 (11)
      * Kshingala: Submission #s 8-14 (7)
      * Rintoro7: Submission #3 (1)
      * Pshaps: Submission #s 1-3 (3)
      * Jenh: Submission #5 (1)
      * Inseonglee: Submission #s 2, 4, 6 (3)
      * Jsapirstein: Submission #s 34, 43-49 (8)
* **Working On:** 
  + 2022\_Fall\_Sally\_Project3 **(1/3 Done from 11AM to 2PM)**
    - 441 Student Submissions
    - 273 Submissions Failed Total
    - Since Project 3 makes use of .bin files, after Issue #1 below is resolved then there will be less submission failures
  + 2022\_Fall\_Sally\_Project4
  + 2022\_Fall\_CS\_3114\_Patrick\_Project1
  + 2022\_Fall\_CS\_3114\_Patrick\_Project2
  + 2022\_Fall\_CS\_3114\_Patrick\_Project3
  + 2022\_Fall\_CS\_3114\_Patrick\_Project4
* Issues
  + Removing .class files but include all other files i.e. .txt files and .bin files because they serve as input for some projects
  + Failed cases where files are under /src directory
    - If not frequent, exclude
    - Else, we find a solution

**Misc Calls:**

python ../.\write\_tasks.py C:\Users\jonny\Desktop\Research\2021\_Summer\_I\_Project\_1\_BigNumArithmetic\_60852\_64375\Project-1 > tasks.ndjson

Python3 .\clone-projects.py tasks.ndjson

python .\pit-runner.py -m all -l tasks.ndjson