Research Report

Hrishikesh Kalyanaraman

2022 Summer SPIN Intern

Mentor: Roland Haas

Undergraduate Student

Engineering Physics, Rising Sophomore

**Project:**

Continuous Integration Testing for the Einstein Toolkit

**Abstract:**

The Einstein Toolkit is a widely used open-source research toolkit for gravitational physics and numerical relativity. The Einstein Toolkit is currently hosted on GitHub. GitHub allows users to develop continuous integration testing for their code. HTML pages that summarize test results are created every time tests are run on the Einstein Toolkit. This project aims to improve the current user functionality of the HTML pages by working on feedback provided by users of the Einstein Toolkit. This included redesigning the main interactive plot in the HTML file, as well as addressing issues found during the testing period. This project also aims to incorporate new code into the current framework, so that automated testing can be applied to the new code in a quicker and more efficient way. This was done on the SelfForcee-1D code. SelfForce-1D now has the capability to run continuous integration pipelines on GitHub using GitHub Actions.

**Introduction:**

The Einstein Toolkit is a community-driven, freely accessible computational infrastructure intended for use in numerical relativity, relativistic astrophysics, and other applications. The Einstein Toolkit was developed by a collaboration from multiple institutes around the world. Today, the Einstein Toolkit boasts approximately 310 users from various institutions around the globe. The Einstein Toolkit consists of around 327 regression tests in 273 modules that continuously developed. The regression tests are run each time new code is added to the Einstein Toolkit. This is done to test the new code for any bugs that might skew scientific results produced by the Einstein Toolkit. This is made possible due to GitHub Actions, a tool present on GitHub, the platform that hosts the Einstein Toolkit.

**Project Goals and Significance:**

The Einstein Toolkit makes use of GitHub actions to develop continuous integration testing. On the Einstein Toolkit, GitHub Actions consists of several workflows which consist of instructions that direct GitHub Actions to perform a series of tasks. One of these workflows instructs Actions to run a python file which creates an HTML file which consists of results obtained from regression testing the new code. The first objective of this project was to improve the overall design and interface of this HTML file. The second objective of this project was to add a new workflow that allowed quicker and cheaper runs. Lastly, this project also required the incorporation of the SelfForce-1D code into the current framework used for the Einstein Toolkit.

**Methodology:**

Firstly, the Einstein Toolkit was cloned to a local machine. The testing process was then replicated to ensure that identical results were obtained on GitHub and the local machine. Then, a trial-and-error process was largely followed. Each time a significant modification was made to the python file that produced the HTML page, the testing process was run locally to ensure that the required results were obtained. Once this was done, the code was then pushed to the GitHub repository. There, workflows on GitHub Actions were manually run to ensure there were no bugs.

**Results:**

The HTML file now contains a redesigned plot that allows users to access all plot information by simply hovering their pointer over each data point. The HTML page now also contains an improved commit table.

Chart

Description automatically generated with medium confidence

Chart, histogram

Description automatically generated

*A set of diagrams that show the differences between the old (top) and new (bottom) plots.*

The Einstein Toolkit now also contains a new python file that helps automate the creation of databases that help store build information. The Einstein toolkit also contains a new workflow that automatically checks for updates in the GitHub repository in any time frame specified by the user.

Table

Description automatically generatedTable

Description automatically generatedSelfForce-1D is a code infrastructure that is used as a black-hole perturbation toolkit. Currently, SelfForce-1D has 4 tests that can be run manually by the user. However, as the toolkit continues to be developed, having a continuous integration system will become vital to the toolkit. The SelfForce-1D code now has python files that enable the creation of HTML files that summarize test results. These python files have been designed to mimic the output produced by the results page of the Einstein Toolkit. These new developments now make it possible for SelfForce-1D to have newly designed workflows that both run and summarize tests.

*Images that show the similarity between the Einstein Toolkit (left) and SelfForce-1D(right)*

**Conclusion:**

This research helped improve the user interface and experience of using the HTML pages that summarize tests run on the Einstein Toolkit. This research also helped create the basis of extending the current Einstein Toolkit functionality to new code like Kuibit or CarpetX. In the future, this research can be continued by researching the compatibility of the Einstein Toolkit with various testing frameworks and adding extra user functionality to the regression tests.

**Sources:**

[Miguel Zilhão](https://arxiv.org/search/gr-qc?searchtype=author&query=Zilh%C3%A3o%2C+M), [Frank Löffler](https://arxiv.org/search/gr-qc?searchtype=author&query=L%C3%B6ffler%2C+F). An Introduction to the Einstein Toolkit. <https://doi.org/10.48550/arXiv.1305.5299>

GitHub. About GitHub Actions. <https://docs.github.com/en/actions/getting-started-with-github-actions/about-github-actions>

Löffler, F., Faber, J., Bentivegna, E., Bode, T., Diener, P., Haas, R., . . . Laguna, P. (2012). The Einstein Toolkit: A community computational infrastructure for relativistic astrophysics. *Classical and Quantum Gravity,* *29* (11), 115001. doi:10.1088/0264-9381/29/11/115001