



Generative AI in Scientific Software and Coding Workshop Series

Session 4: Debugging Scientific Code with LLMs: Using GitHub CoPilot for Debugging

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Hosted by
NSF-NCAR's Computational & Information Systems Lab (CISL)

Code of Conduct

Here we value respectful dialogue, please...



Expected Behavior:

- All participants are treated with respect and consideration, valuing a diversity of views and opinions
- Be considerate, respectful, and collaborative
- Communicate openly with respect for others, critiquing ideas rather than individuals

Please contact Jessica Wang (jessicawang@ucar.edu) or Taysia Peterson (taysia@ucar.edu) if you experience any issues or have questions.

Future Workshop Sessions

Save the date!

Session 5: Dec 3rd, 2:00 – 3:00 pm MT, Remote
Sustainability, Energy Use, and Environmental Impacts of Training and
Using LLMs
Speaker : Pengfei Lu



Registration Link: <https://ncar.pub/nhug-genai>

You only need to register once!

GitHub CoPilot for Business License for NCAR Users

- Join the NCAR GitHub Organization: <https://github.com/NCAR>
- Coordinate with your lab's budgeting for a project key (billing key) for charging CoPilot Charges (\$19/month).
- Submit a Help Request:
 - Create a request through the NCAR/UCAR Service Desk by emailing help@ucar.edu or using the Service Desk portal.
 - Provide your **GitHub ID** and **Project Key** for charging CoPilot charges.

The Service Desk will process your request, confirm the billing information, and activate the license.

Note: NCAR only offers GitHub Copilot for Business, not the Enterprise tier.

Traditional methods of debugging

- Error messages from compiler or runtime
- Use Google, stack overflow, blog posts, forums
- Print statements
- Debuggers
- Unit tests, logging, documentation, etc.

Debugging with CoPilot

- CoPilot is most effective when paired with traditional debugging
- Use CoPilot to speedup the traditional methods of debugging
- CoPilot gives you summarized view of the information that you are looking for

Types of Errors

Syntax Errors

- Incorrect syntax
- Typos

Logical Errors

- Incorrect logic
- Off-by-one errors

Runtime Errors

- Null pointer
- Divide by zero
- Array out of bounds

Compilation Errors

- Type mismatch
- Missing dependencies

Performance Issues

- Inefficient algorithms
- Memory leaks

Configuration Issues

- Incorrect configuration files
- Environment setup

Concurrency Issues

- Race conditions
- Deadlocks

Integration Issues

- API mismatches
- Dependency conflicts

Security Issues

- SQL injection
- Cross-site scripting (XSS)

Types of Errors Example/Demo

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Example 1 – Syntax Errors

- Declaration and Initialization of variables section
- Missing allocatable in declaration
- Typos in the variable names

Syntax Errors

- Incorrect syntax
- Typos

Demo with Code: Kernel extracted from MPAS-A dynamical core

Example 2 – Logical Errors

Logical Issues are hard to debug but CoPilot can help make it simpler

- Writing unit tests to track down the logic error
- Print statement and assertions
- If you use a Debugger, it can suggest breakpoints and inspect variables, give contextual information about the variables

Logical Errors

- Incorrect logic
- Off-by-one errors

Demo with Code: MiniWeather app

Example 3 – Runtime Errors

- Null pointer and other pointer issues
- Divide by 0
- Array out of bounds issue

Runtime Errors

- Null pointer and other pointer issues
- Divide by zero
- Array out of bounds

Demo with Code: Earthworks, Kernel
extracted from MPAS-A dynamical core

Example 4 – Compilation Errors

- Missing libraries while building the code
- Debugging issues with building libraries
- Type mismatch issues
 - Operations on objects of a type or a class
 - Addition of float and int without type cast

Compilation Errors

- Type mismatch
- Missing dependencies

Demo with Code: MiniWeather,
Parallel-netcdf

Example 5 – Performance Issues

- Recognizing row and column major for the best performance of a language
- Checking for memory leaks by tracking down variables allocation and deallocation

Performance Issues

- Inefficient algorithms
- Memory leaks

Demo with Code: Kernel extracted from MPAS-A dynamical core -Fortran

Example 6 – Configuration Issues

- Validate the configuration for scientific correctness before running the computation part
 - Using Assertion, logging, and validation function
- Environment set for building and running a code
 - Lets try an example C++ application
 - Example code, Makefile, Docker container, CI workflow, some functions, unit tests, documentation

Configuration Issues

- Incorrect configuration files
- Environment setup

Concurrency Issues

- Race conditions
- Deadlocks

Integration Issues

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Security Issues

- SQL injection
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Summary

- CoPilot is robust in identifying, fixing or suggesting things to try
- CoPilot can be used to significantly speed up the application debugging
- Don't completely rely on CoPilot to debug your application (at least not yet)
- Pairing CoPilot with traditional debugging is a better approach than either just using traditional methods or completely relying on CoPilot
- CoPilot can give you wrong answers depending on the context and prompt - Give additional context and/or change the prompt