HPS

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Impact of GIL-less Cpython

Table of contents

1 Introduction

2 Compatibility Insights

3 Performance Benchmarks

4 Analysis

5 Challenges and Next Steps

What's New In Python 3.13

- JIT compiler
- Clearer error messages
- Minor upgrades to Python's static type system
- Improvements made to the interactive interpreter (REPL)
- Experimental support for free-threaded mode (PEP 703)

Recap: Why GIL-less CPython Matters

- Definition of GIL: Mutex in CPython that limits Python to execute one thread at a time.
- Why it exists: Simplifies memory management and avoids race conditions in CPython's reference counting.
- Prevents multi-threaded performance gains in CPU-bound workloads.
- Threads benefit mostly from I/O-bound tasks (e.g., file operations, web requests).

Porting Python Packages to Support Free-Threading

(For C, C++, Cython, Rust)

- Declare compatibility
- Ensure thread safety
- Test thoroughly
- Handle global state
- Verify dependencies
- In pure Python: Mostly, no changes are required.

Declaring NoGIL Compatibility

How to explicitly declare your library supports NoGIL:

- C/C++: Use `Py_mod_gil` or `PyUnstable_Module_SetGIL`.
- pybind11: Add `gil_not_used`.
- Cython: Set `freethreading_compatible=True`.
- Rust (PyO3): Use `gil_used = false`.

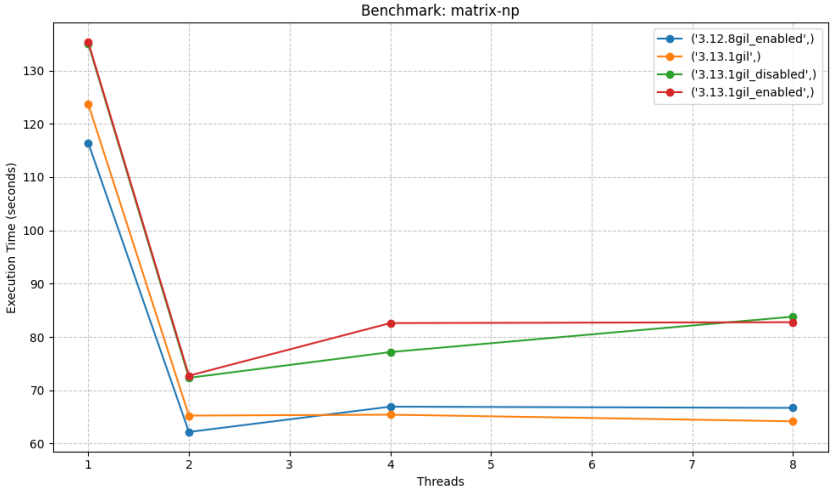
Compatibility List

- *Python 3.13 Readiness*
- Shows Python 3.13 support for the 360 most downloaded packages on PyPI
- 129 green packages (35.8%) support Python 3.13;
- 231 uncolored packages (64.2%) don’t explicitly support Python 3.13 yet.

Performance Benchmarks: Setup

- Four benchmark categories:
  - `3.12.8`: Newest Python version before 3.13
  - `3.13.1−gil`: Compiled with the old threading model (GIL)
  - `3.13.1gil_enabled`: Compiled with new threading model, GIL enabled
  - `3.13.1gil_disabled`: Compiled with new threading model, GIL disabled
- 1,2,4,8 threads
- Tests show the average value of 5 runs each.

Performance Benchmarks: Numpy Matrix Multiplication



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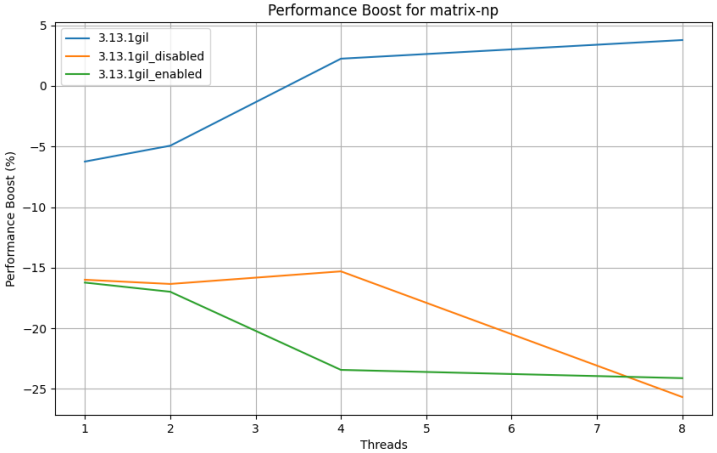
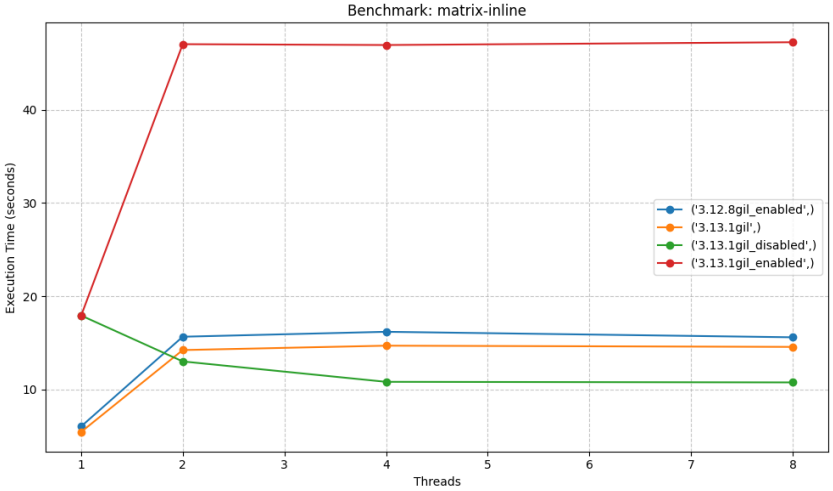


Performance Benchmarks: Pure Python Matrix Multiplication



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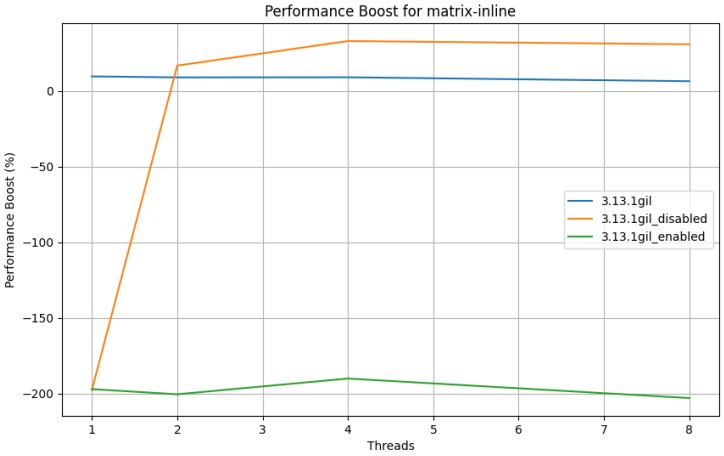
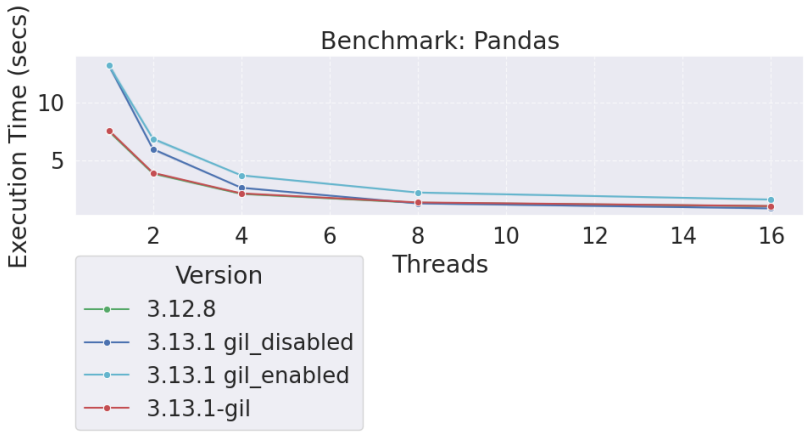


Performance Benchmarks: Pandas (Filter, Mean, Merge, Lambda)



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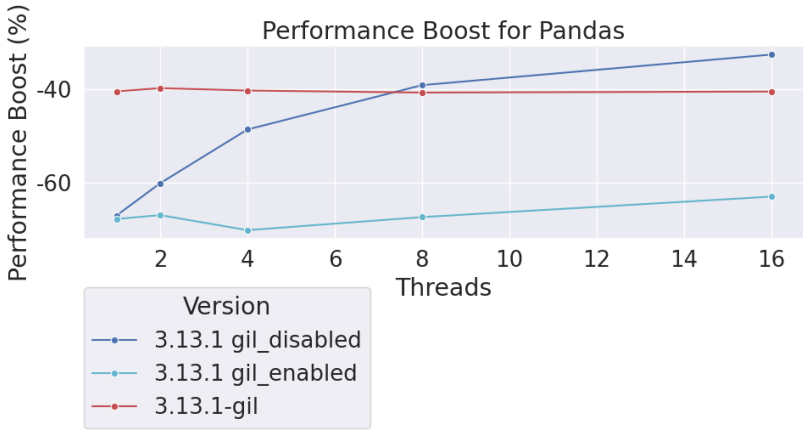
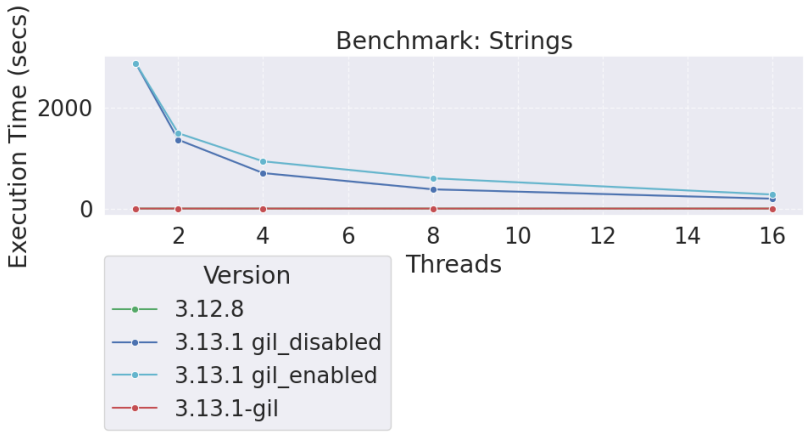


Performance Benchmarks: Strings



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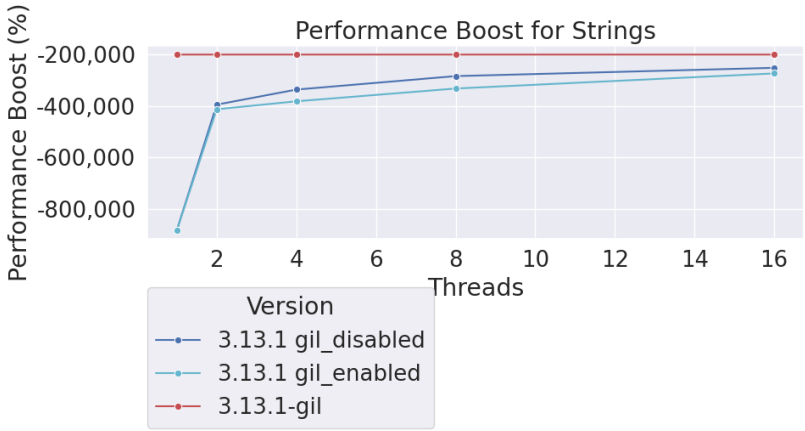
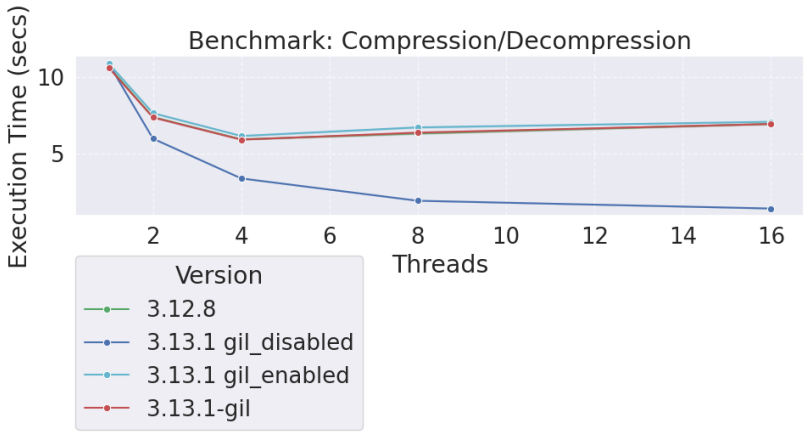


Performance Benchmarks: Compress, Decompress



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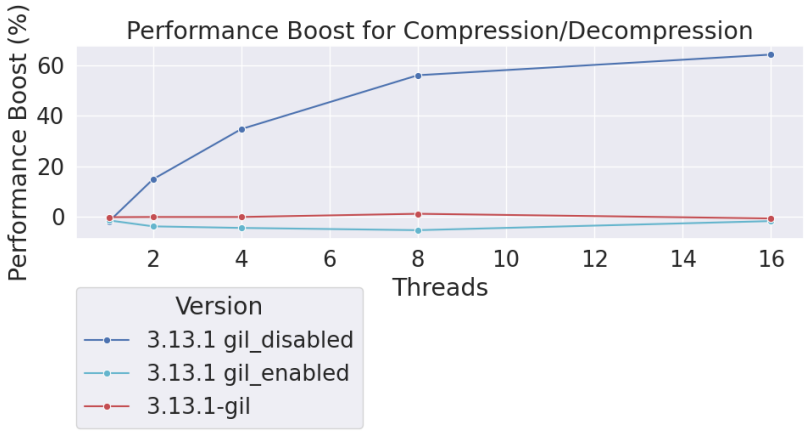
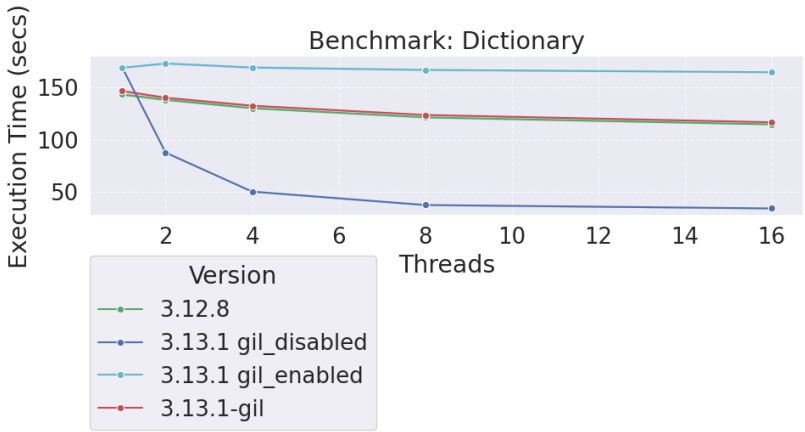


Performance Benchmarks: Dictionary (Intersection, Union)



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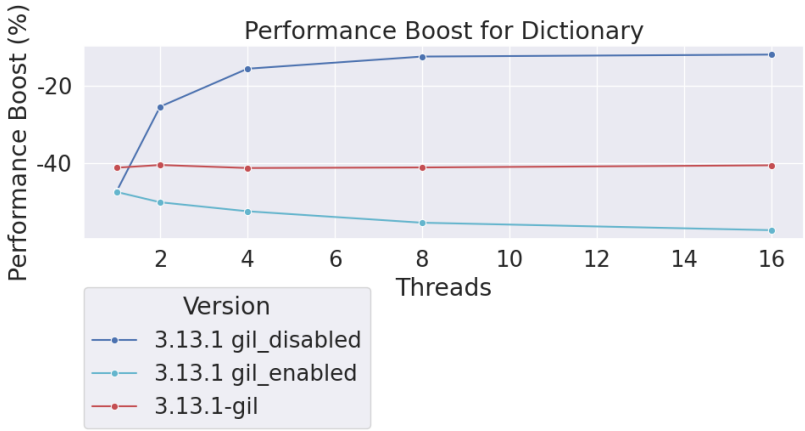
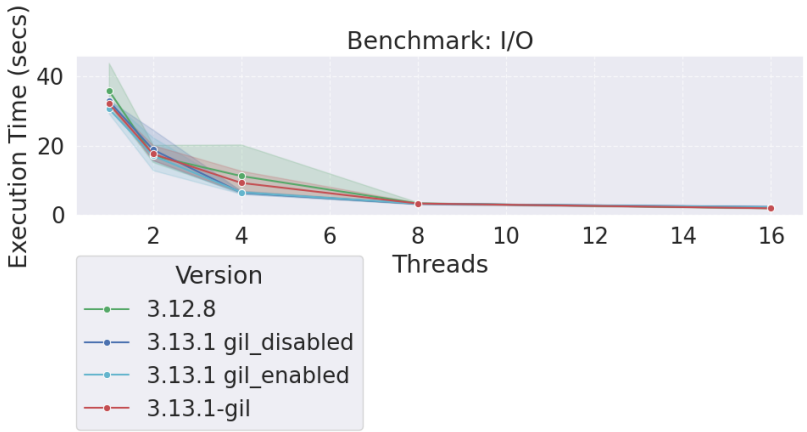


Performance Benchmarks: I/O



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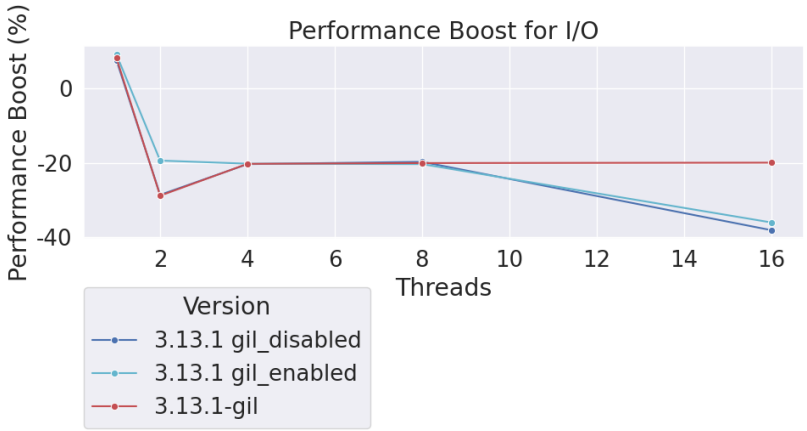
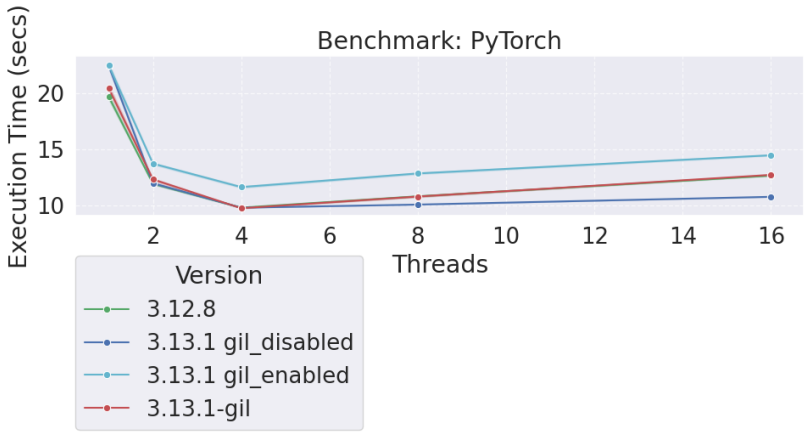


Performance Benchmarks: PyTorch



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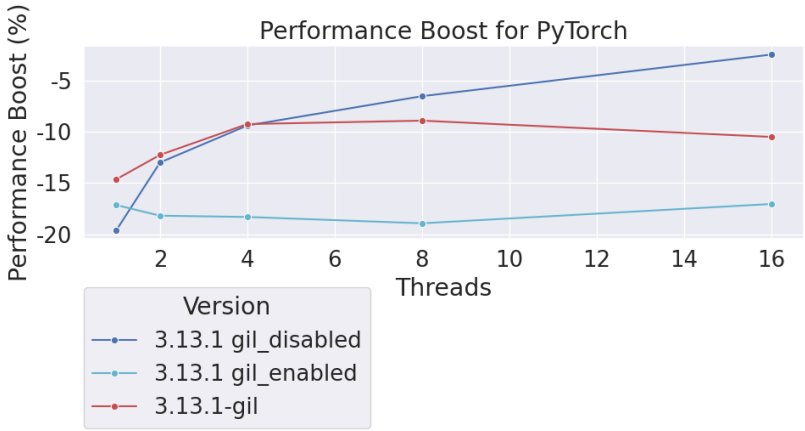

Performance Benchmarks

- (GIL) Worse Performance for:
  - Numpy
  - String operations (not in the graphs)
- (GIL) Better Performance for:
  - Pure Python Matrix Multiplication
  - Pandas
  - Compress, Decompress
  - Dictionary (Intersection, Union)

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- Benefits:
  - Better scalability when working with large data operations.
- Challenges:
  - Worse performance for the new interpreter with GIL enabled.
  - Increased synchronization costs for some workloads.

Challenges and Next Steps

- More tests on communication overhead.
- Benchmark Python 3.14 to look for further improvements (especially the bug fix for string operations)

Conclusion

Key Takeaways:

- GIL-less Python delivers performance gains for some pure-python workloads.
- Libraries like Numpy do not get any noticeable performance improvements.
- Compatibility issues are manageable but require ecosystem-wide cooperation.

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