Exposing the TestU01 and PractRand PRNG test suites to scientific libraries via Python

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Objectives

Bring the collection of PRNGs and Statistical Tests from the *TestU01* and *PractRand* libraries to Python, to assist scientific research on PRNG security.

- Determine the best method to pass arguments to generators and tests using the most idiomatic Python.
- Employ macro-based code generation to simplify logic.
- Create a common interface for returning test results.
- Support cross-library generator & test interoperability.

Project Status

- Exposed all generators and tests from *TestU01* and *PractTand* via Python.
- Re-implemented the SmallCrush *TestU01* battery and the *PractRand* Core and Expanded Tests battery.
- Implemented unit testing for new logic.
- Developed basic support for interoperability testing PRNG data via files.

Background: PRNG Test Suites

Pseudorandom Number Generators (**PRNGs**) are an essential component of many practical secure applications.

Security of PRNGs is assessed (broadly) via two approaches: (1) mathematical proofs and (2) statistical tests

Collections of tools exist to support (2), including the:

- NIST Statistical Test Suite
- Dieharder Test Suite
- Diehardest Test Suite
- TestU01 Test Suite
- PractRand Test Suite

The **evaluation** of the efficacy of each tool is an active line of research, hindered by: interfaces limiting direct access to test outputs, incomparable test outputs, incomparable test runners.

Pyhardest

The goal of **Pyhardest** is to **expose existing PRNG test suite logic via Python** —

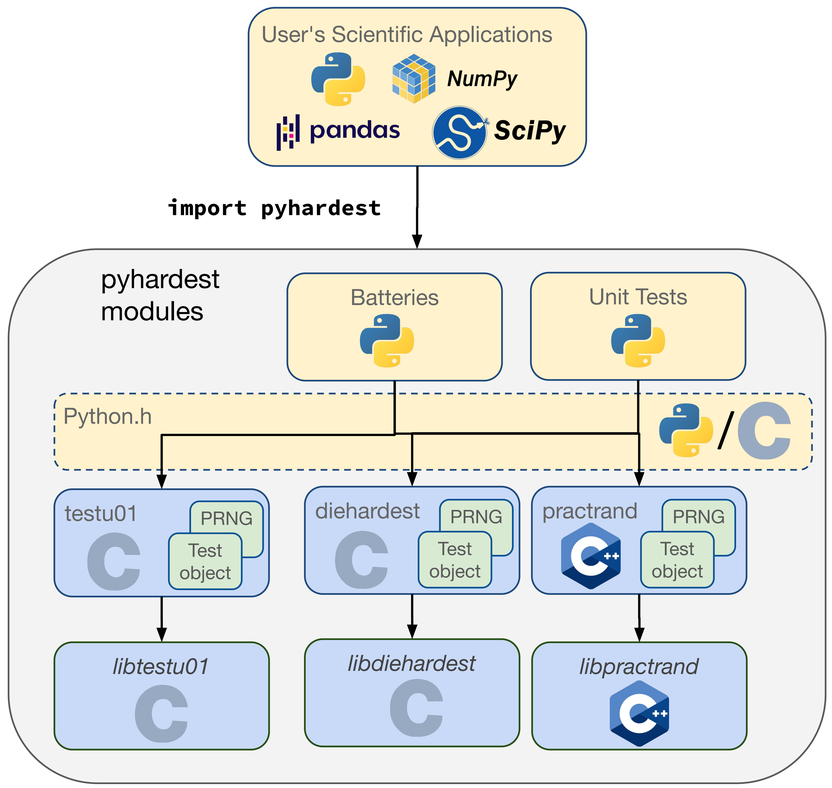
- leverage data science tools available in Python ecosystem
- facilitate apples-to-apples comparisons of suites
- develop new methods to prototype test runner logic

Python Binding of PRNGs and Tests

Exposing test suites allows us to

- Better organize results returned by tests and batteries
- Leverage a common interface for result analysis
- Explore new methods of visualization
- Implement popular test batteries directly in Python
- Experiment with new methods of dynamic testing
- Leverage more standardized unit testing frameworks

Figure: pyhardest library structure



Shown above are three wrapped PRNG libraries and Python unit tests and battery implementations.

- Each library wrapper is organized in its own module
- Provides own interface

Figure: Example of how TestU01 functions are wrapped

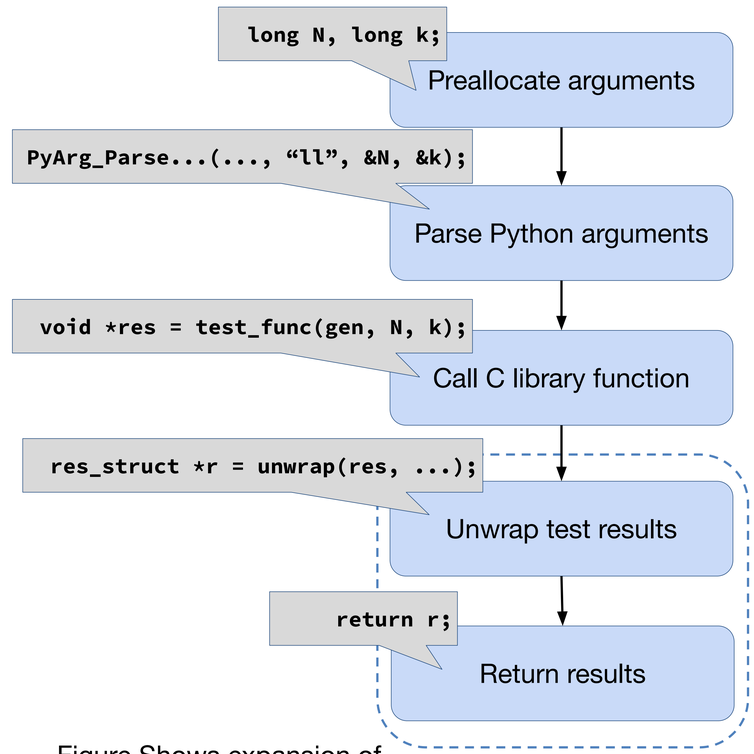


Figure Shows expansion of

```
TESTU01_TEST2(test_func, "ll",
              long, N, long, k)
```

Code Generation using Macros

Determined code generation approach would best promote code reuse and readability.

- Implemented using compiler preprocessor macros
- Performs bounds checking for C library functions
- Unwraps C struct results into Python dictionaries

Summary of Exposed Logic

Test Suite	PRNGs	Tests
TestU01	188	58
PractRand	169	26
Total	357	84

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Future Work

The *pyhardest* project is still a work-in-progress. Ideas of extending these achievements include

- Productizing the project to be distributable via pip
- Enhancing interoperability of tests and PRNGs
- Creating common documentation generation and interface using Sphinx