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 PractRand 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
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: Example of how TestU01 functions are wrapped

```c
long N, long k;
PyArg_Parse...(,..., "ll", &N, &k);
```

```c
void *res = test_func(gen, N, k);
res_struct *r = unwrap(res, ...);
return r;
```

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

<table>
<thead>
<tr>
<th>Test Suite</th>
<th>PRNGs</th>
<th>Tests</th>
</tr>
</thead>
<tbody>
<tr>
<td>TestU01</td>
<td></td>
<td>188</td>
</tr>
<tr>
<td>PractRand</td>
<td></td>
<td>169</td>
</tr>
<tr>
<td>Total</td>
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<td>357</td>
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Acknowledgments
This work was funded under the SSU Research, Scholarship and Creative Activities Program. Thank you Robert G. Brown (Duke University) for special permission to adapt tests from Dieharder under a permissive license.