CHANGELOG

[v1.1.0] - 2026-02-08

Added

- Introduced configurable softening parameters epsilon (ε) in simulation constants.
- Added runtime parameter validation for $\varepsilon > 0$.
- Added runtime parameter for Barnes-Hut approximation theta (θ).
- Added tangential friction to colliding/touching objects.
- Added OpenGL based anim library to visualize simulation resolving I/O bottleneck.

Changed

- Modified gravitational force equation from classical newtonian form to softened form.
- Migrated from direct-sum algorithm to Barnes-Hut approximation algorithm improving performance for high N-body simulations
- Migrated from SLOP/ impulse based collision handling to spring like collision improving stability.

Fixed

- Resolved segmentation faults that occur when objects leave simulation bounds.
- Resolved energy pump bug that gave colliding objects tangential energy.
- Resolved explosive squeeze effect that occurs when an object is crushed from both ends.
- Resolved memory leak issues from local heap arrays.
- Resolved forced serialization from I/O operations when the program is running over multiple threads.

Deprecated

- Removed SLOP/Impulse collision handling.
- Removed I/O Anim functionality.

Performance Notes

- Minor increase in arithmetic from additional softening terms.
- Improved long-term energy stability for dense initial conditions.
- Increased overhead for Barnes Hut Tree building
- Significant improvement in anim performance.

Notes for Developers

- Recommended default for epsilon is 0.01. Larger values will result in over softening.
- Recommended default for theta is 0.05. Larger values are less accurate. 0 will result in a direct sum (slowest but most accurate)
- Since visualization is now handled within the library itself it must be compiled alongside the program. Dependencies differ between Mac, Linux, and Windows computers please check Make file for more information.

Backwards compatibility

- Any program that made use of earlier versions of the library will still compile without changes. However, unless specified, it will use default parameters for epsilon and theta which may result in different outcomes.

Known Issues

- The new openGL anim library has frame pacing issues with simulation fewer than a 100 bodies.