GEORG-AUGUST-UNIVERSITÄT
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Scientific Computing

Approximation of π

Prepared by

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Project Statement

This project, completed by Abdul Halim, explores the implementation and comparison of various computational methods for approximating the mathematical constant π. The primary focus was on developing robust algorithms and leveraging Python to create an efficient and scientifically accurate framework. The project reflects a deep engagement with numerical methods, software development, and performance analysis in scientific computing.

Purpose

The aim of this project was to investigate multiple approximation techniques for π, evaluate their computational efficiency, and document their relative strengths. The methods chosen offer diverse approaches, including geometric, probabilistic, and series-based techniques. These techniques are applicable in various fields, such as numerical analysis, statistical simulations, and mathematical research.

Key Objectives

1. **Development of Numerical Classes:**
   - Implemented classes for rational numbers, floating-point numbers, and fixed-precision numbers.
   - Ensured compatibility with Python standards for arithmetic operations, comparisons, and precision control.
2. **Implementation of Approximation Methods:**
   - Geometric approximations using polygons.
   - Polygon method, BBP, Newton method, Monte Carlo methods, including Buffon's needle problem.
   - Iterative and series-based methods, such as the Bailey–Borwein–Plouffe formula.
3. **Performance Analysis:**
   - Compared the efficiency and accuracy of methods using Python's benchmarking tools.
   - Analyzed computational trade-offs and documented findings in a scientific manner.
4. **Comprehensive Documentation:**
   - Created a detailed Jupyter Notebook with explanations, visualizations, and results.
   - Followed scientific best practices, including thorough referencing and structured reporting.

Applications

The methodologies developed in this project have potential applications in:

- High-precision calculations in scientific research.
- Statistical simulations and probabilistic modeling.
- Educational tools for demonstrating numerical approximations of mathematical constants.

Impact and Future Work

This project highlights the effectiveness of combining numerical methods with modern programming tools to solve mathematical problems. Future directions include extending the framework to parallelized computations, exploring machine learning for adaptive method selection, and applying these techniques to approximate other mathematical constants or solve related numerical problems.

Abdul Halim's work showcases a commitment to advancing scientific computing through rigorous algorithm development and thoughtful analysis.