Fractional Eigenbasis Compression Placeholder Title

<Author 1>
<Institution 1>
<City 1>, <State 1>
<E-mail1>

<Author 2>
<Institution 1>
<City 1>, <State 1>
<E-mail2>

<Author 3>
<Institution 1>
<City 1>, <State 1>
<E-mail3>

ABSTRACT

In order to study the non-local diffusion operator known as the fractional laplacian, we have developed a framework to solve a simple fractional poisson problem using the spectral expansion method. This framework requires computation of a set of eigenpairs for the given problem geometry. For analytical purposes, we compute the entire eigenbasis in order to explore the impact of the non-local nature of the fractional laplacian on the convergence of the spectral expansion. Additionally, we employ the zfp compression library to reduce the amount of data required to store the full eigenbasis. Using this compression library, we explore strategies for balancing data reduction and performance impact in addition to leveraging any aspect of the non-local operator to improve either data reduction or performance.

This abstract will be updated as results are put into the paper. "We will explore" statements will be replaced with more concrete statements about results.

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1 INTRODUCTION

<Project motivation>

<Introduce fractional operators>

<Introduce Nektar++>

<Introduce SLEPc>

<Introduce zfp>

2 FRACTIONAL LAPLACIAN

<Define fractional poisson problem>

<Define spectral approach to solving fractional poisson problem>

<Describe non-local nature of fractional properties and what aspects can and can not be captured by the spectral approach>

3 EIGENBASIS COMPUTATION

<Justify need for full eigenbasis>

3.1 Method

<Describe discretization using Nektar++ to get stiffness and mass matrices>

<Describe usage of SLEPc to solve for all eigenpairs within a given interval>

<Motivate need for spectrum slicing>

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3.1.1 Spectrum Slicing. <Describe spectrum slicing as a method to break the full eigenbasis computation into independent partial eigenbasis computations>

<Motivate need for our communication hierarchy>

<Define evaluator>

<Describe load imbalance that occurs if total interval is divided evenly among evaluators>

<Describe round-robin distribution of subintervals to available evaluators>

3.1.2 Counting an Interval. <Describe exact counting technique>

<Describe approximate counting technique>

3.1.3 Post-Processing and Orthogonalization. <Describe post-processing orthogonalization step>

<Give complexity estimate for post-processing step and justify>

3.2 Results

<Linear relationship between number of eigenvalues in an interval and the time it takes to solve that interval>

<Performance scaling with respect to number of evaluators (up to the maximum I have access to on rmacc-summit) and problem size>

<Orthogonality results without post-processing>

<Load imbalance results with respect to number of subproblems per evaluator>

<Comparison of performance and accuracy of exact and approximate interval counting>

3.3 Potential Improvements

<PETSc/SLEPc supported GPU acceleration to take full advantage of available computing resources>

<Describe how even if GPU-accelerated eigenvalue solve sees no performance gain over CPU, it can function as an extra evaluator resulting in further ability to divide work>

<Explain that load imbalance is mostly minimized, however, with the addition of GPU evaluators, it may be necessary to implement a task queue to ensure that an evaluator is only idle if there is no more work available for anyone>

4 EIGENBASIS STORAGE AND COMPRESSION

<Details about zfp compression>

4.1 Method

<Describe Eigenbasis data structure and the available storage modes>

<Explain that each storage mode also corresponds to a compression strategy>

<Describe how the Eigenbasis is applied and truncation criteria>

4.2 Results

<Compare compression strategies; Data reduction and time to compress/decompress>

5 RESULTS

<Present results relating to the performance of applying the Eigenbasis using the various compression and storage strategies>

<Present results relating to the accuracy of spectral approach with various truncation criteria>

6 CONCLUSION

REFERENCES