MOLE Documentation

Release 1.0.0

MOLE Development Team

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DOCUMENTATION

CHAPTER

ONE

WELCOME TO MOLE (MIMETIC OPERATORS LIBRARY ENHANCED)

MOLE is a comprehensive library for numerical computations focusing on mimetic difference methods.

CHAPTER

TWO

KEY FEATURES

- Mimetic difference operators
- Support for various boundary conditions
- High-performance numerical computations
- Cross-platform compatibility (C++ and MATLAB implementations)
- Extensive example collection

CHAPTER THREE

CONTENTS

3.1 Introduction

Welcome to the introduction to MOLE (Mimetic Operators Library Enhanced).

This section provides a high-level overview of the library's goals, purpose, and major features. The MOLE library aims to deliver robust, efficient, and maintainable numerical operators for mimetic difference methods.

3.1.1 Key Features

- **Mimetic Operators**: Support for divergence, gradient, curl, and other core operators.
- **Boundary Conditions**: Easily set Dirichlet, Neumann, and Robin boundary conditions.
- **High-Performance Computation**: Uses efficient linear algebra libraries like Armadillo.
- **Cross-Language Support**: API available for both **C++** and **MATLAB**.
- **Documentation & Examples**: Includes tutorials, usage examples, and implementation guides.

Continue reading the **C++ API** and **MATLAB API** documentation for in-depth technical usage and examples.

3.2 C++ API Documentation

The **MOLE C++ API** provides low-level access to the mimetic operators and boundary condition functions. This section describes the core classes, functions, and examples for utilizing the API in your C++ applications.

3.2.1 Table of Contents

- **Divergence Class**: Handles the computation of divergence operators.
- **Gradient Class**: Computes the gradient of scalar fields.
- **Laplacian Class**: Supports Laplacian operations on grid-based structures.
- **Boundary Conditions**: Manage Dirichlet, Neumann, and Robin boundary conditions.

3.2.2 C++ API Reference

class **`Divergence`** : public sp_mat

#include `<divergence.h>` Mimetic `Divergence` operator.

Public Functions

`Divergence``(`u16 k, u32 m, `Real` dx`)`

1-D Mimetic `Divergence` Constructor

Parameters

- **`k`** – Order of accuracy
- **`m`** – Number of cells
- **`dx`** – Spacing between cells

`Divergence``(`u16 k, u32 m, u32 n, `Real` dx, `Real` dy`)`

2-D Mimetic `Divergence` Constructor

Parameters

- **`k`** – Order of accuracy
- **`m`** – Number of cells in x-direction
- **`n`** – Number of cells in y-direction
- **`dx`** – Spacing between cells in x-direction
- **`dy`** – Spacing between cells in y-direction

`Divergence``(`u16 k, u32 m, u32 n, u32 o, `Real` dx, `Real` dy, `Real` dz`)`

3-D Mimetic `Divergence` Constructor

Parameters

- **`k`** – Order of accuracy
- **`m`** – Number of cells in x-direction
- **`n`** – Number of cells in y-direction
- **`o`** – Number of cells in z-direction
- **`dx`** – Spacing between cells in x-direction
- **`dy`** – Spacing between cells in y-direction
- **`dz`** – Spacing between cells in z-direction

vec **`getQ`**`()`

Returns the weights used in the Mimeitc `Divergence` Operators.

Note

for informational purposes only, can be used in constructing new operators.

Private Members

vec **Q**

class **Gradient** : public sp_mat

#include <gradient.h> Mimetic `Gradient` operator.

Public Functions

Gradient(u16 k, u32 m, `Real` dx)

1-D Mimetic `Gradient` Constructor

Parameters

- **k** – Order of accuracy
- **m** – Number of cells
- **dx** – Spacing between cells

Gradient(u16 k, u32 m, u32 n, `Real` dx, `Real` dy)

2-D Mimetic `Gradient` Constructor

Parameters

- **k** – Order of accuracy
- **m** – Number of cells in x-direction
- **n** – Number of cells in y-direction
- **dx** – Spacing between cells in x-direction
- **dy** – Spacing between cells in y-direction

Gradient(u16 k, u32 m, u32 n, u32 o, `Real` dx, `Real` dy, `Real` dz)

3-D Mimetic `Gradient` Constructor

Parameters

- **k** – Order of accuracy
- **m** – Number of cells in x-direction
- **n** – Number of cells in y-direction
- **o** – Number of cells in z-direction
- **dx** – Spacing between cells in x-direction

- **`dy`** – Spacing between cells in y-direction
- **`dz`** – Spacing between cells in z-direction

vec **`getP()`**

Returns the weights used in the Mimeitc `Gradient` Operators.

Note

for informational purposes only, can be used in constructing new operators.

Private Members

vec **`P`**

class **`Interpol`** : public sp_mat

#include <*`interpol.h`*> Mimetic Interpolator operator.

Public Functions

`Interpol``(`u32 m, `Real` c`)`

1-D Mimetic Interpolator Constructor

Parameters

- **`m`** – Number of cells
- **`c`** – Weight for ends, can be any value from 0.0<=c<=1.0

`Interpol``(`u32 m, u32 n, `Real` c1, `Real` c2`)`

2-D Mimetic Interpolator Constructor

Parameters

- **`m`** – Number of cells in x-direction
- **`n`** – Number of cells in y-direction
- **`c1`** – Weight for ends in x-direction, can be any value from 0.0<=c<=1.0
- **`c2`** – Weight for ends in y-direction, can be any value from 0.0<=c<=1.0

`Interpol``(`u32 m, u32 n, u32 o, `Real` c1, `Real` c2, `Real` c3`)`

3-D Mimetic Interpolator Constructor

Parameters

- **`m`** – Number of cells in x-direction
- **`n`** – Number of cells in y-direction
- **`o`** – Number of cells in z-direction

- **c1** – Weight for ends in x-direction, can be any value from 0.0<=c<=1.0
- **c2** – Weight for ends in y-direction, can be any value from 0.0<=c<=1.0
- **c3** – Weight for ends in z-direction, can be any value from 0.0<=c<=1.0

Interpol(bool type, u32 m, `Real` c)

1-D Mimetic Interpolator Constructor

Parameters

- **type** – Dummy holder to trigger overloaded function
- **m** – Number of cells
- **c** – Weight for ends, can be any value from 0.0<=c<=1.0

Interpol(bool type, u32 m, u32 n, `Real` c1, `Real` c2)

2-D Mimetic Interpolator Constructor

Parameters

- **type** – Dummy holder to trigger overloaded function
- **m** – Number of cells in x-direction
- **n** – Number of cells in y-direction
- **c1** – Weight for ends in x-direction, can be any value from 0.0<=c<=1.0
- **c2** – Weight for ends in y-direction, can be any value from 0.0<=c<=1.0

Interpol(bool type, u32 m, u32 n, u32 o, `Real` c1, `Real` c2, `Real` c3)

3-D Mimetic Interpolator Constructor

Parameters

- **type** – Dummy holder to trigger overloaded function
- **m** – Number of cells in x-direction
- **n** – Number of cells in y-direction
- **o** – Number of cells in z-direction
- **c1** – Weight for ends in x-direction, can be any value from 0.0<=c<=1.0
- **c2** – Weight for ends in y-direction, can be any value from 0.0<=c<=1.0
- **c3** – Weight for ends in z-direction, can be any value from 0.0<=c<=1.0

class **Laplacian** : public sp_mat

#include <*laplacian.h*> Mimetic `Laplacian` operator.

Public Functions

`Laplacian`(u16 k, u32 m, `Real` dx)

1-D Mimetic `Laplacian` Constructor

Parameters

- **`k`** – Order of accuracy
- **`m`** – Number of cells
- **`dx`** – Spacing between cells

`Laplacian`(u16 k, u32 m, u32 n, `Real` dx, `Real` dy)

2-D Mimetic `Laplacian` Constructor

Parameters

- **`k`** – Order of accuracy
- **`m`** – Number of cells in x-direction
- **`n`** – Number of cells in y-direction
- **`dx`** – Spacing between cells in x-direction
- **`dy`** – Spacing between cells in y-direction

`Laplacian`(u16 k, u32 m, u32 n, u32 o, `Real` dx, `Real` dy, `Real` dz)

3-D Mimetic `Laplacian` Constructor

Parameters

- **`k`** – Order of accuracy
- **`m`** – Number of cells in x-direction
- **`n`** – Number of cells in y-direction
- **`o`** – Number of cells in z-direction
- **`dx`** – Spacing between cells in x-direction
- **`dy`** – Spacing between cells in y-direction
- **`dz`** – Spacing between cells in z-direction

class **`MixedBC`** : public sp_mat

#include <*`mixedbc.h`*> Mimetic Mixed Boundary Condition operator.

Public Functions

`MixedBC`(u16 k, u32 m, `Real` dx, const std::string &left, const std::vector<`Real`> &coeffs_left, const std::string &right, const std::vector<`Real`> &coeffs_right)

1-D Constructor

Parameters

- **k** – Order of accuracy
- **m** – Number of cells
- **dx** – Spacing between cells
- **left** – Type of boundary condition at the left boundary ('Dirichlet', 'Neumann', 'Robin')
- **coeffs_left** – Coefficients for the left boundary condition
- **right** – Type of boundary condition at the right boundary ('Dirichlet', 'Neumann', 'Robin')
- **coeffs_right** – Coefficients for the right boundary condition

MixedBC(u16 k, u32 m, Real dx, u32 n, Real dy, const std::string &left, const std::vector<Real> &coeffs_left, const std::string &right, const std::vector<Real> &coeffs_right, const std::string &bottom, const std::vector<Real> &coeffs_bottom, const std::string &top, const std::vector<Real> &coeffs_top)

2-D Constructor

Parameters

- **k** – Order of accuracy
- **m** – Number of cells along x-axis
- **dx** – Spacing between cells along x-axis
- **n** – Number of cells along y-axis
- **dy** – Spacing between cells along y-axis
- **left** – Type of boundary condition at the left boundary ('Dirichlet', 'Neumann', 'Robin')
- **coeffs_left** – Coefficients for the left boundary condition
- **right** – Type of boundary condition at the right boundary ('Dirichlet', 'Neumann', 'Robin')
- **coeffs_right** – Coefficients for the right boundary condition
- **bottom** – Type of boundary condition at the bottom boundary ('Dirichlet', 'Neumann', 'Robin')
- **coeffs_bottom** – Coefficients for the bottom boundary condition
- **top** – Type of boundary condition at the top boundary ('Dirichlet', 'Neumann', 'Robin')
- **coeffs_top** – Coefficients for the top boundary condition

`MixedBC`(u16 k, u32 m, `Real` dx, u32 n, `Real` dy, u32 o, `Real` dz, const std::string &left, const std::vector<`Real`> &coeffs_left, const std::string &right, const std::vector<`Real`> &coeffs_right, const std::string &bottom, const std::vector<`Real`> &coeffs_bottom, const std::string &top, const std::vector<`Real`> &coeffs_top, const std::string &front, const std::vector<`Real`> &coeffs_front, const std::string &back, const std::vector<`Real`> &coeffs_back)

3-D Constructor

Parameters

- **`k`** – Order of accuracy
- **`m`** – Number of cells along x-axis
- **`dx`** – Spacing between cells along x-axis
- **`n`** – Number of cells along y-axis
- **`dy`** – Spacing between cells along y-axis
- **`o`** – Number of cells along z-axis
- **`dz`** – Spacing between cells along z-axis
- **`left`** – Type of boundary condition at the left boundary ('Dirichlet', 'Neumann', 'Robin')
- **`coeffs_left`** – Coefficients for the left boundary condition
- **`right`** – Type of boundary condition at the right boundary ('Dirichlet', 'Neumann', 'Robin')
- **`coeffs_right`** – Coefficients for the right boundary condition
- **`bottom`** – Type of boundary condition at the bottom boundary ('Dirichlet', 'Neumann', 'Robin')
- **`coeffs_bottom`** – Coefficients for the bottom boundary condition
- **`top`** – Type of boundary condition at the top boundary ('Dirichlet', 'Neumann', 'Robin')
- **`coeffs_top`** – Coefficients for the top boundary condition
- **`front`** – Type of boundary condition at the front boundary ('Dirichlet', 'Neumann', 'Robin')
- **`coeffs_front`** – Coefficients for the front boundary condition
- **`back`** – Type of boundary condition at the back boundary ('Dirichlet', 'Neumann', 'Robin')
- **`coeffs_back`** – Coefficients for the back boundary condition

class **`RobinBC`** : public sp_mat

#include <`robinbc.h`> Mimetic Robin Boundary Condition operator.

Public Functions

`RobinBC(u16 k, u32 m, Real dx, Real a, Real b)`

1-D Robin boundary constructor

Parameters

- **k** – mimetic order of accuracy
- **m** – number of cells in x-dimension
- **dx** – cell width in x-direction
- **a** – Coefficient of the Dirichlet function
- **b** – Coefficient of the Neumann function

`RobinBC(u16 k, u32 m, Real dx, u32 n, Real dy, Real a, Real b)`

2-D Robin boundary constructor

> **Note**
>
> Uses 1-D Robin to build the 2-D operator

Parameters

- **k** – mimetic order of accuracy
- **m** – number of cells in x-dimension
- **dx** – cell width in x-direction
- **n** – number of cells in y-dimension
- **dy** – cell width in y-direction
- **a** – Coefficient of the Dirichlet function
- **b** – Coefficient of the Neumann function

`RobinBC(u16 k, u32 m, Real dx, u32 n, Real dy, u32 o, Real dz, Real a, Real b)`

3-D Robin boundary constructor

> **Note**
>
> Uses 1-D Robin to build the 3-D operator

Parameters

- **k** – mimetic order of accuracy
- **m** – number of cells in x-dimension
- **dx** – cell width in x-direction

- **n** – number of cells in y-dimension
- **dy** – cell width in y-direction
- **o** – number of cells in z-dimension
- **dz** – cell width in z-direction
- **a** – Coefficient of the Dirichlet function
- **b** – Coefficient of the Neumann function

class **Utils**

#include <*utils.h*> Utility Functions.

Public Functions

void **meshgrid**(const vec &x, const vec &y, mat &X, mat &Y)

An analog to the MATLAB 2D meshgrid operation.

returns 2-D grid coordinates based on the coordinates contained in vectors x and y. X is a matrix where each row is a copy of x, and Y is a matrix where each column is a copy of y. The grid represented by the coordinates X and Y has length(y) rows and length(x) columns. Key here is the rows is the y-coordinate, and the columns are the x-coordinate.

Parameters

- **x** – a vector of x-indices
- **y** – a vector of y-indices
- **X** – a sparse matrix, will be filled by the function
- **Y** – a sparse matrix, will be filled by the function

void **meshgrid**(const vec &x, const vec &y, const vec &z, cube &X, cube &Y, cube &Z)

An analog to the MATLAB 3D meshgrid operation.

meshgrid(x,y,z,X,Y,Z) returns 3-D grid coordinates defined by the vectors x, y, and z. The grid represented by X, Y, and Z has size length(y)-by-length(x)-by-length(z).

Parameters

- **x** – a vector of x-indices
- **y** – a vector of y-indices
- **z** – a vector of z-indices
- **X** – a sparse matrix, will be filled by the function
- **Y** – a sparse matrix, will be filled by the function
- **Z** – a sparse matrix, will be filled by the function

Public Static Functions

static sp_mat **spkron**(const sp_mat &A, const sp_mat &B)

A wrappper for implementing a sparse Kroenecker product.

Note

This is available in Armadillo >8.0

Parameters

- **A** – a sparse matrix
- **B** – a sparse matrix

static sp_mat **spjoin_rows**(const sp_mat &A, const sp_mat &B)

An in place operation for joining two matrices by rows.

Note

This is available in Armadillo >8.0

Parameters

- **A** – a sparse matrix
- **B** – a sparse matrix

static sp_mat **spjoin_cols**(const sp_mat &A, const sp_mat &B)

An in place operation for joining two matrices by columns.

Note

This is available in Armadillo >=8.5

Parameters

- **A** – a sparse matrix
- **B** – a sparse matrix

static vec **spsolve_eigen**(const sp_mat &A, const vec &b)

A wrappper for implementing a sparse solve using Eigen from SuperLU.

Note

This function requires the EIGEN to be used when Armadillo is built

Parameters

- **`A`** – a sparse matrix LHS of Ax=b
- **`b`** – a vector for the RHS of Ax=b

namespace **`arma`**

file **`README.md`**

file **`divergence.cpp`**

#include "`divergence.h`"

file **`divergence.h`**

#include "`utils.h`"#include <cassert>

file **`gradient.cpp`**

#include "`gradient.h`"

file **`gradient.h`**

#include "`utils.h`"#include <cassert>

file **`interpol.cpp`**

#include "`interpol.h`"

file **`interpol.h`**

#include "`utils.h`"#include <cassert>

file **`laplacian.cpp`**

#include "`laplacian.h`"

file **`laplacian.h`**

#include "`divergence.h`"#include "`gradient.h`"

file **`mixedbc.cpp`**

#include "`mixedbc.h`"

file **`mixedbc.h`**

#include "`gradient.h`"

file **mole.h**

#include “`divergence.h`”#include “`gradient.h`”#include “`interpol.h`”#include “`laplacian.h`”#include “`mixedbc.h`”#include “`operators.h`”#include “`robinbc.h`”#include “`utils.h`”

file **operators.h**

#include “`interpol.h`”#include “`laplacian.h`”#include “`mixedbc.h`”#include “`robinbc.h`”

Functions

inline sp_mat **operator***(const `Divergence` &div, const `Gradient` &grad)

inline sp_mat **operator+**(const `Laplacian` &lap, const `RobinBC` &bc)

inline sp_mat **operator+**(const `Laplacian` &lap, const `MixedBC` &bc)

inline vec **operator***(const `Divergence` &div, const vec &v)

inline vec **operator***(const `Gradient` &grad, const vec &v)

inline vec **operator***(const `Laplacian` &lap, const vec &v)

inline vec **operator***(const `Interpol` &I, const vec &v)

file **robinbc.cpp**

#include “`robinbc.h`”

file **robinbc.h**

#include “`gradient.h`”

file **utils.cpp**

#include “`utils.h`”#include <cassert>

file **utils.h**

#include <armadillo>

Defines

UTILS_H

Typedefs

using **Real** = double

dir **src/cpp**

dir **src**

page **MOLE: Mimetic Operators Library Enhanced**

1: Description

MOLE is a high-quality (C++ & MATLAB/Octave) library that implements high-order mimetic operators to solve partial differential equations. It provides discrete analogs of the most common vector calculus operators: `Gradient`, `Divergence`, `Laplacian`, Bilaplacian, and Curl. These operators (highly sparse matrices) act on staggered grids (uniform, non-uniform, curvilinear) and satisfy local and global conservation laws.

Mathematics is based on the work of Corbino and Castillo, 2020[1]. However, the user may find helpful previous publications, such as Castillo and Grone, 2003[2], in which similar operators were derived using a matrix analysis approach.

2: Licensing

MOLE is distributed under a GNU General Public License; please refer to the *LICENSE* file for more details.

3: Installation

3.1 Packages Required

To install the MOLE library on your system, certain packages must be installed and configured beforehand. The required packages vary by operating system.

For the macOS, Homebrew needs to be installed to download the required packages. Invoke the following command in the terminal app

```
/bin/bash -c "$(curl -fsSL https://raw.githubusercontent.com/
↪Homebrew/install/HEAD/install.sh)"
```

Remove Java dependencies

```
brew uninstall --ignore-dependencies java
```

Update Homebrew again

```
brew update
```

If you encounter errors during Homebrew installation, please run the following commands before the installation:

```
sudo chown -R $(whoami) /usr/local/Cellar
git -C /usr/local/Homebrew/Library/Taps/homebrew/homebrew-core␣
↪fetch --unshallow
```

3.1.1 CMake

Minimum Version Required: 3.10

For Ubuntu systems:

sudo apt install cmake *For Mac Systems*

brew install cmake *For Yum-based systems:*

sudo yum install cmake

3.1.2 OpenBLAS

Minimum Version Required: OpenBLAS 0.3.10

For Ubuntu systems:

sudo apt install libopenblas-dev *For Mac Systems*

brew install openblas *For Yum-based systems:*

sudo yum install openblas-devel

3.1.3 Eigen3

Minimum Version Required: eigen-3

For Ubuntu systems

sudo apt install libeigen3-dev *For Mac Systems*

brew install eigen *For Yum-based systems:*

sudo yum install eigen3-devel

3.1.4 libomp

For Mac Systems

brew install libomp

3.1.5 LAPACK

For Mac Systems

brew install lapack

3.2 MOLE Library Installation

Clone the MOLE repository and build the library

```
git clone https://github.com/csrc-sdsu/mole.git
cd mole
mkdir build && cd build
```

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```
cmake ..
make
```

To install the library in a custom location (Eg. home/mole)

cmake &#8212;install . &#8212;prefix /path/to/location

To install the library in a previledged location (Eg. /opt/mole)

sudo cmake &#8212;install . Or

sudo cmake &#8212;install . &#8212;prefix /path/to/privileged/location

To run the C++ tests manually,

```
make run_tests
```

To run the matlab tests manually,

```
make run_matlab_tests
```

Armadillo and SuperLu will be locally installed in the build directory once the cmake .. command is passed. By following the steps outlined above, you will successfully install the necessary packages and the MOLE library on your system. The library will be installed in the location provided. The tests and examples to be executed will also be built locally inside the build directory.

4: Running Examples & Tests

Here are instructions on how to run the provided examples and tests for both the C++ and MATLAB versions of the library to help you quickly get started with MOLE.

- **tests/cpp:** These tests, which are automatically executed upon constructing the library's C++ version, play a crucial role in verifying the correct installation of MOLE and its dependencies. There are four tests in total.
- **tests/matlab:** We encourage MATLAB users to execute these tests before using MOLE by entering the `tests/matlab` directory and executing `run_tests.m` from MATLAB. These tests are analogous to those contained in `tests/cpp`.
- **examples/cpp:** These will be automatically built after calling `make`. We encourage C++ users to make this their entry point to familiarize themselves with this library version. The four examples are self-contained and adequately documented, and they solve typical PDEs.
- **examples/matlab:** Most of our examples are provided in the MATLAB scripting language. Over 30 examples range from linear one-dimensional PDEs to highly nonlinear multidimensional PDEs.

5: Documentation

For detailed documentation, including API references, tutorials, and examples, please refer to our Documentation Guide.

NOTE: Performing non-unary operations involving operands constructed over different grids may lead to unexpected results. While MOLE allows such operations without throwing errors, users must exercise caution when manipulating operators across different grids.

6: Community Guidelines

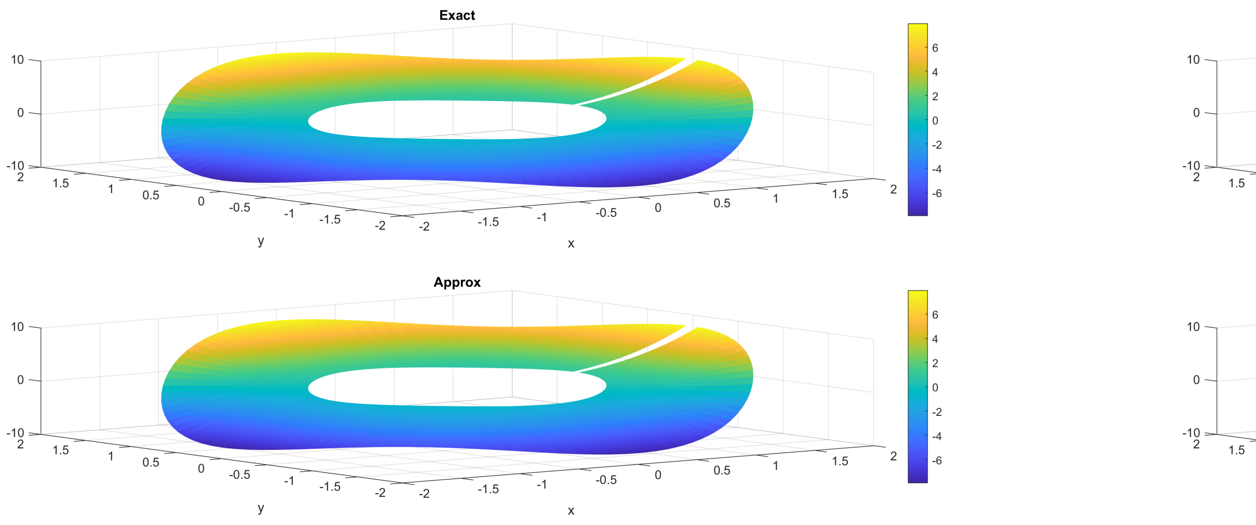
We welcome contributions to MOLE, whether they involve adding new functionalities, providing examples, addressing existing issues, reporting bugs, or requesting new features. Please refer to our Contribution Guidelines[3] for more details.

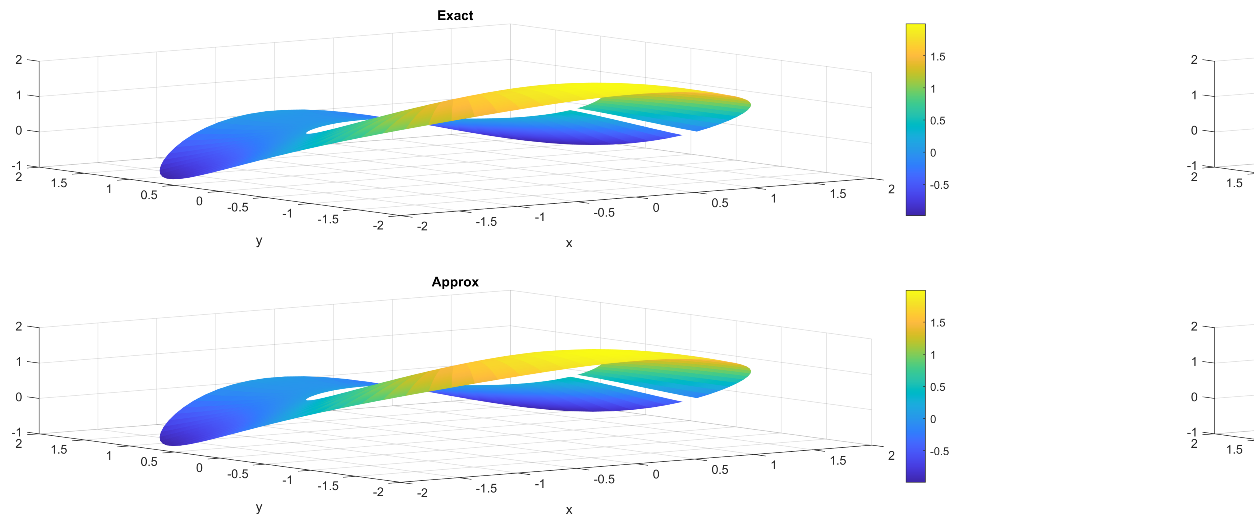
7: Citations

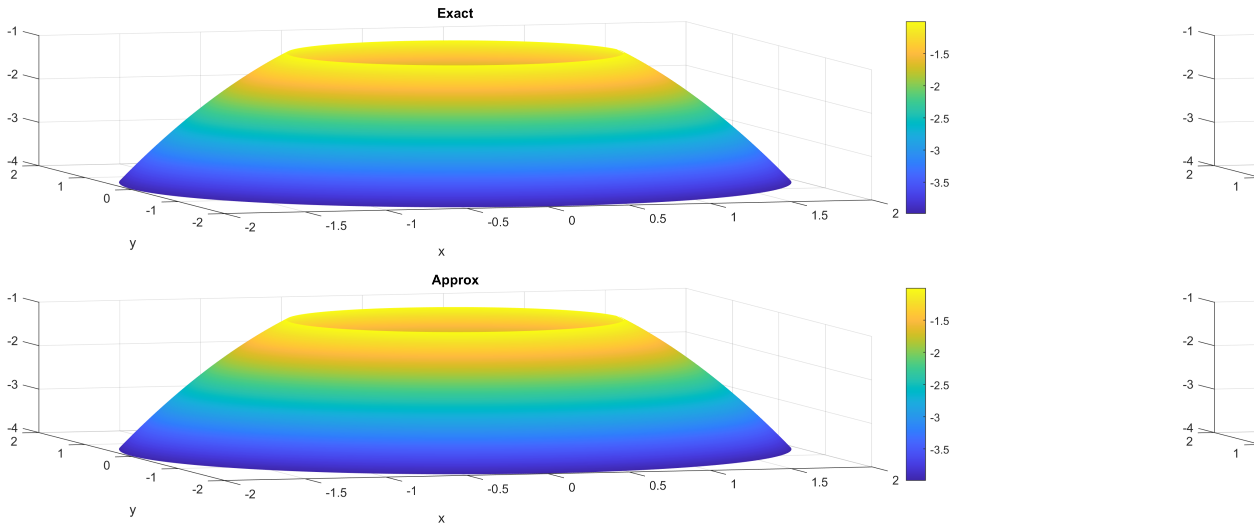
Please cite our work if you use MOLE in your research or software. Citations are helpful for the continued development and maintenance of the library [4]

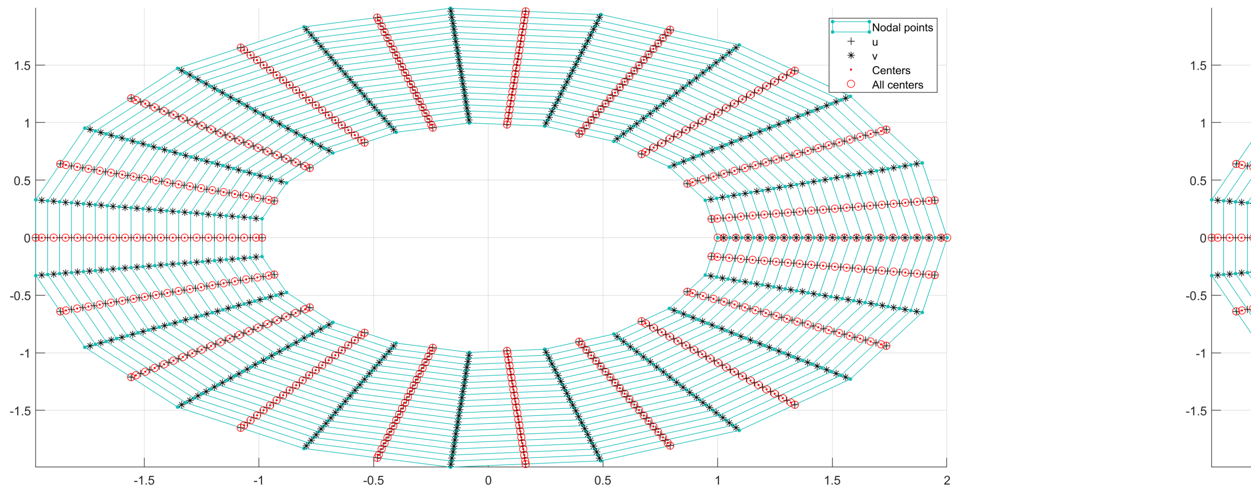
5

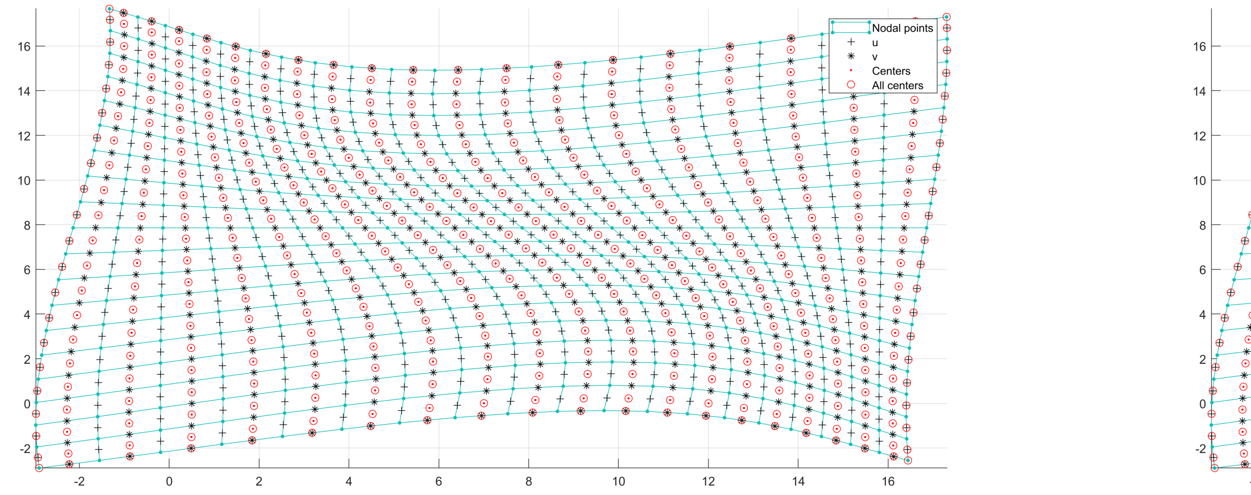
Now, some cool pictures obtained with MOLE:

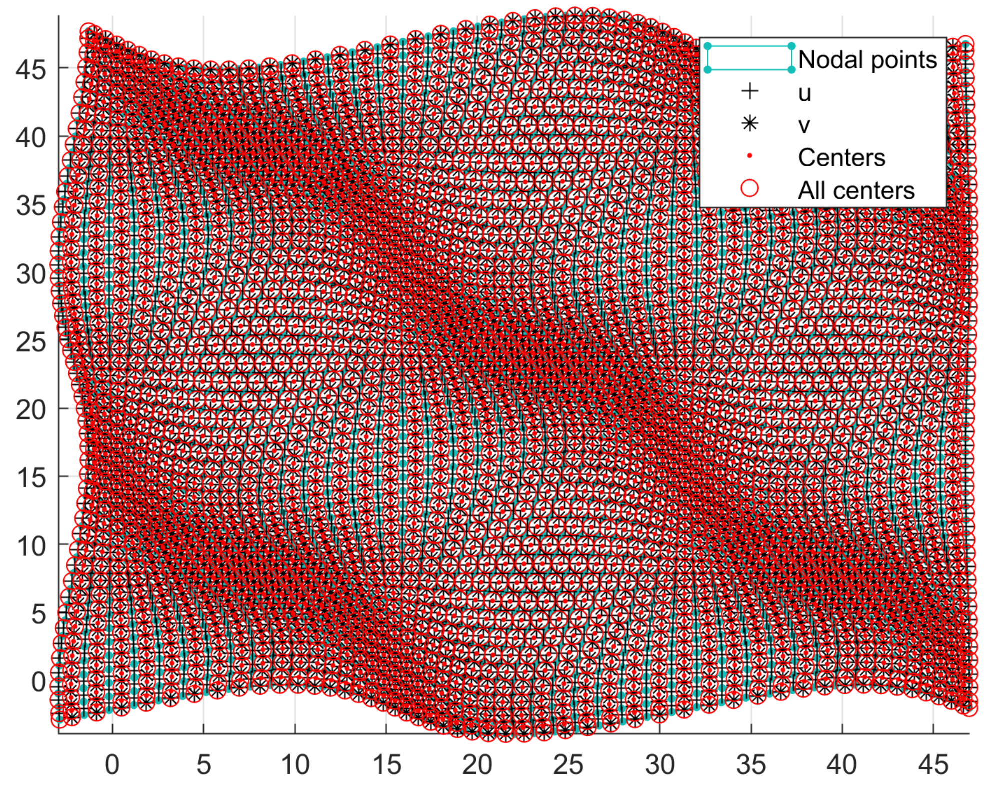


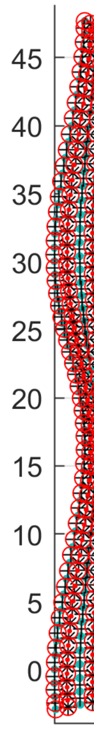

Exact
Approx
x
y


Exact
Approx
x
y


Nodal points
u
v
Centers
All centers
1.5
1
0.5
0
-0.5
-1
-1.5
-1.5
-1
-0.5
0
0.5
1
1.5
2


Nodal points
u
v
Centers
All centers
16
14
12
10
8
6
4
2
0
-2
-2
0
2
4
6
8
10
12
14
16


Nodal points
u
v
Centers
All centers
45
40
35
30
25
20
15
10
5
0
0
5
10
15
20
25
30
35
40
45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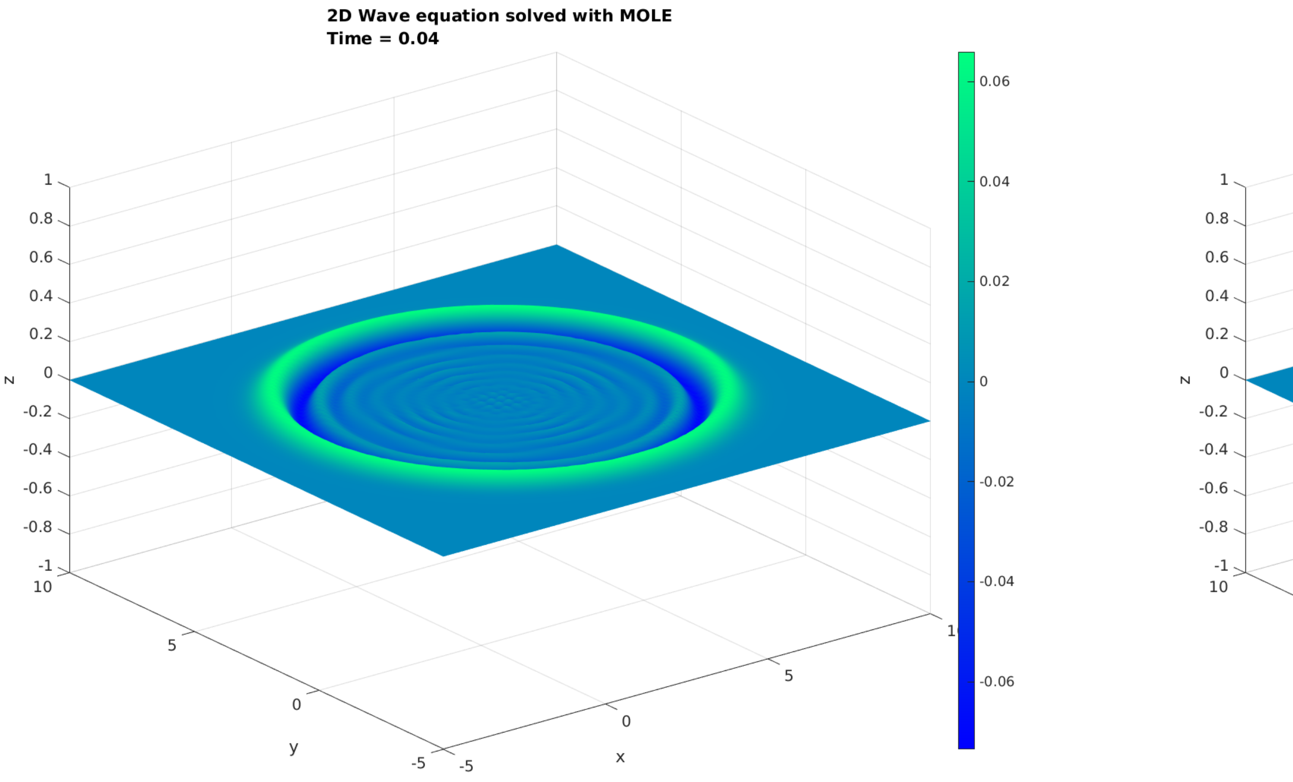

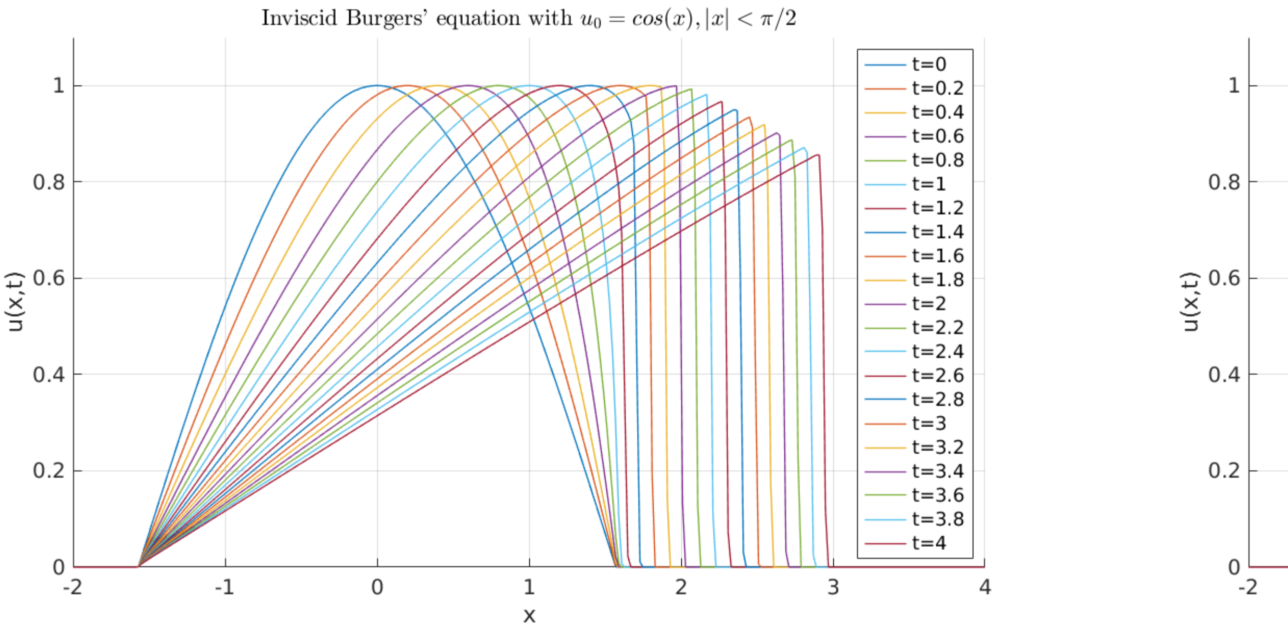

[1] https://doi.org/10.1016/j.cam.2019.06.042
[2] https://doi.org/10.1137/S0895479801398025
[3] https://github.com/csrc-sdsu/mole/blob/master/CONTRIBUTING.md
[4] https://doi.org/10.21105/joss.06288
[5] https://www.mathworks.com/matlabcentral/fileexchange/124870-mole

3.3 MATLAB API Documentation

The **MATLAB API** for MOLE provides access to mimetic operators, solvers, and pre-processing routines within MATLAB. This API allows MATLAB users to leverage the computational power of C++-based mimetic operators while working in a familiar MATLAB environment.

3.3.1 Key Functions

- **Divergence**: Computes the divergence of a vector field.
- **Gradient**: Computes the gradient of a scalar field.
- **Laplacian**: Computes the Laplacian of a field.
- **Boundary Conditions**: Set boundary conditions directly in MATLAB scripts.

3.3.2 Reference Documentation

The MATLAB API documentation can be found at the link below: MATLAB API Reference

3.4 Getting Started

This guide will help you get started with MOLE.

3.4.1 Installation

3.4.1.1 Prerequisites

- C++17 compatible compiler
- CMake 3.10 or higher
- MATLAB (optional, for MATLAB API)

3.4.1.2 Building from Source

1. Clone the repository:

```
git clone https://github.com/csrc-sdsu/mole.git
cd mole
```

2. Build the library:

```
make
```

3.5 Contributing Guide

3.5.1 Contributing to MOLE

Thank you for considering contributing to MOLE! We appreciate your interest and support. Here are some guidelines to help you get started:

3.5.1.1 1. Contributing to MOLE

- **Fork the Repository**: Start by forking the MOLE repository to your GitHub account.
- **Create a Branch**: Create a new branch for your feature or bug fix.
- **Make Your Changes**: Implement your changes and open a pull request with a clear description.

3.5.1.2 2. Reporting Issues or Problems

If you encounter any issues or bugs, please report them by following these steps:

- **Check for Existing Issues**: Before creating a new issue, please check the issue tracker[6] to see if the problem has already been reported.
- **Create a New Issue**: If the issue has not been reported, create a new issue with a clear and descriptive title.

3.5.1.3 3. Seeking Support

For support requests or general questions, please feel free to reach out to us via email at johnnycorbino@gmail.com, angelboada2@gmail.com, and jcastillo@sdsu.edu.

Thank you for your contributions and support!

3.6 Code of Conduct

3.6.1 Contributor Covenant Code of Conduct

3.6.1.1 Our Pledge

In the interest of fostering an open and welcoming environment, we as contributors and maintainers pledge to making participation in our project and our community a harassment-free experience for everyone, regardless of age, body size, disability, ethnicity, gender identity and expression, level of experience, nationality, personal appearance, race, religion, or sexual identity and orientation.

3.6.1.2 Our Standards

Examples of behavior that contributes to creating a positive environment include:

- Using welcoming and inclusive language
- Being respectful of differing viewpoints and experiences
- Gracefully accepting constructive criticism
- Focusing on what is best for the community
- Showing empathy towards other community members

Examples of unacceptable behavior by participants include:

[6] `https://github.com/jcorbino/mole/issues`

- The use of sexualized language or imagery and unwelcome sexual attention or advances
- Trolling, insulting/derogatory comments, and personal or political attacks
- Public or private harassment
- Publishing others' private information, such as a physical or electronic address, without explicit permission
- Other conduct which could reasonably be considered inappropriate in a professional setting

3.6.1.3 Our Responsibilities

Project maintainers are responsible for clarifying the standards of acceptable behavior and are expected to take appropriate and fair corrective action in response to any instances of unacceptable behavior.

Project maintainers have the right and responsibility to remove, edit, or reject comments, commits, code, wiki edits, issues, and other contributions that are not aligned to this Code of Conduct, or to ban temporarily or permanently any contributor for other behaviors that they deem inappropriate, threatening, offensive, or harmful.

3.6.1.4 Scope

This Code of Conduct applies both within project spaces and in public spaces when an individual is representing the project or its community. Examples of representing a project or community include using an official project e-mail address, posting via an official social media account, or acting as an appointed representative at an online or offline event. Representation of a project may be further defined and clarified by project maintainers.

3.6.1.5 Enforcement

Instances of abusive, harassing, or otherwise unacceptable behavior may be reported by contacting the project team at johnnycorbino@gmail.com. The project team will review and investigate all complaints, and will respond in a way that it deems appropriate to the circumstances. The project team is obligated to maintain confidentiality with regard to the reporter of an incident. Further details of specific enforcement policies may be posted separately.

Project maintainers who do not follow or enforce the Code of Conduct in good faith may face temporary or permanent repercussions as determined by other members of the project's leadership.

3.6.1.6 Attribution

This Code of Conduct is adapted from the Contributor Covenant[7], version 1.4, available at http://contributor-covenant.org/version/1/4[8]

[7] `http://contributor-covenant.org`
[8] `http://contributor-covenant.org/version/1/4/`

CHAPTER

FOUR

INDICES AND TABLES

- genindex
- search

CHAPTER

FIVE

MORE INFORMATION

- genindex
- modindex
- search

INDEX