

## Running Mace4 with the Isomorphic Cubes Algorithms

### Software Requirement

The Mace4 executable is compiled in C++ version 11, and scripts are written in Python 3.8. They are tested in Linux computers:

Linux 4.19.0-6-amd64 #1 SMP Debian 4.19.67-2+deb10u1 (2019-09-20) x86\_64  
GNU/Linux

### File Organization

top directory

```
|-- bin          # directory for executables
    |-- mace4     # Mace 4 executable
|-- p9m4         # top working directory
    |-- inputs    # Mace4 inputs files
    |-- utils
        |-- mace          # scripts to generate models
            |-- bootstrap.py # top script to kick off model enumeration process
            |-- extend_cubes.py # functions to extend the length of cubes using Mace4
            |-- multi_cube_analyzer.py # helper functions to remove isomorphic cubes
            |-- iso_cubes.py # functions to check for isomorphism between cubes
            |-- run_cubes.py # functions to execute Mace4 to enumerate models
            |-- some other scripts for future use and for testing
```

### Model Enumeration

The algebra supported are listed in bootstrap.py, and the input files in Mace4 format are in .../p9m4/inputs. Edit bootstrap.py to specify the algebra, order, and the desired target cube length. E.g. to enumerate all models of semigroups of order 7, using cubes of length 25:

```
algebra = "semi"
target_cube_length = 25
order = 7
```

The supported cube lengths for each type of algebra are listed at the top of the file bootstrap.py. For example, semigroups contains only 1 binary and the supported cube lengths are:

```
cube_sequence_2 = [2, 4, 9, 16, 25, 36, 49, 64]
```

All parameters for running semigroups is in the following entry in the run\_data dictionary:

```
'semi': {'seq': cube_sequence_2, 'relations': [False],
          'input': 'semi', 'arities': [2], 'radius': r_2, 'remove': -1},
```

To run the script, issue the command in the `.../p9m4` directory

```
utils/mace4/bootsctrp.py
```

To clean up the working directory after the run, issue the command in the `.../p9m4` directory:

```
rm -rf *_working_*  
rm -rf utils/mace4/working
```