Code Acceleration of the Calculation of Influence Coefficients of Nemoh Deployment Guide

Revision History

Author	Revision Number	Date
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Deployment Instructions

1. Organization of Submission

Nemoh/ Contains the modified source of Nemoh Fortran software
docs/ Contains this deployment guide
docs/GreenFunctionDerivativeODE.pdf Contains ODE for the derivative of the green function
NemohPython/ Contains the modified Nemoh python code
README.txt note about testing previous old Fortran code

2. Application Setup

Linux

- GCC with GFortran >= 4.8

- BLAS
- LAPACK
- OpenMP provided by GCC
- HDF5 >=1.8.11 http://www.hdfgroup.org/HDF5/ Optionally provided by Anaconda
- HDFView http://www.hdfgroup.org/products/java/release/download.html
- Python 2.7 Optionally provided by Anaconda
- H5py >= 2.3.1 Optionally provided by Anaconda
- Numpy Optionally provided by Anaconda
- Cmake >= 4.8 http://www.cmake.org/cmake/resources/software.html
- Anaconda (with Python 2.7) >= 2.1.0 http://continuum.io/downloads

Windows

- MinGW 4.8.1 http://sourceforge.net/projects/MinGWbuilds/files/host-windows/releases/4.8.1/
- BLAS http://icl.cs.utk.edu/lapack-for-windows/lapack/#libraries
- LAPACK http://icl.cs.utk.edu/lapack-for-windows/lapack/#libraries
- OpenMP provided by MinGW
- HDF5 >=1.8.11 http://www.hdfgroup.org/HDF5/ Optionally provided by Anaconda
- HDFView http://www.hdfgroup.org/products/java/release/download.html
- Python 2.7 Optionally provided by Anaconda
- H5py >= 2.3.1 Optionally provided by Anaconda
- Numpy Optionally provided by Anaconda
- Cmake >= 4.8 http://www.cmake.org/cmake/resources/software.html
- Anaconda (with Python 2.7) >= 2.1.0 http://continuum.io/downloads

MAC OS X

- Brew http://brew.sh/
- GCC >= 4.8 installed by brew
- XCode Command Line Tools installed by brew
- BLAS provided by Xcode commands

- LAPACK Provided by Xcode commands
- OpenMP provided by GCC
- HDF5 >=1.8.11 http://www.hdfgroup.org/HDF5/ Optionally provided by Anaconda
- HDFView http://www.hdfgroup.org/products/java/release/download.html
- Python 2.7 Optionally provided by Anaconda
- H5py >= 2.3.1 Optionally provided by Anaconda
- Numpy Optionally provided by Anaconda
- Cmake >= 4.8 installed by brew
- Anaconda (with Python 2.7) >= 2.1.0 http://continuum.io/downloads

Variables

Let's call:
$NEMOH_FORTRAN the directory Nemoh/ in the root of the submission directory
$NEMOH_PYTHON the directory NemohPython/
$FORTRAN_BUILD the build directory for the FORTRAN version of Nemoh
$MINGW_ROOT the directory where MINGW will be installed

3. Configuration

The python code can be configured using the file **$NEMOH_PYTHON/nemoh/settings.py**
Newly added properties are in red

Property	Definition	Example
USE_ODE_INFLUENCE_COEFFICIENTS	Indicate whether or not to use the ode method to compute the influence coefficients	True
GREEN_TABULATION_NUMX	Number of points in x direction of tabulated data	500
GREEN_TABULATION_NUMZ	Number of points in z direction of tabulated data	60
GREEN_TABULATION_SIMPSON_NPOINTS	Number of sub intervals used to approximate the green function integral using simpson rule	551
HDF5_FILE	The path to the hdf5 file where to save and load the results and input. Required	'db.hdf5' No need to change
NEMOH_CALCULATIONS_FILE	The old nemoh calculation file. Not required but it is needed to automatically convert the old Nemoh.cal file to hdf5 storage	'Nemoh.cal' No need to change but then make sure you have the nemoh calculation file Nemoh.cal in your working directory. Also make sure the path to the

Property	Definition	Example
		mesh file references in Nemoh.cal exists. For exemple if in the Nemoh.cal file you have 'Cylinder.dat', then you should have the Cylinder.dat file in your current directory
NEMOH_INPUT_FILE	Same as above but applied to the nemoh input file	'input.txt' No need to change but then make sure you have the nemoh input file input.txt in your working directory
NEMOH_INT	Represents the integer type to use when performing computations. It should be a valid numpy integer type. See http://docs.scipy.org/doc/numpy/reference/arrays.scalars.html#arrays-scalars-built-in for possible values	'i'
NEMOH_FLOAT	Represents the float type to use when performing computations. It should be a valid numpy float type. See http://docs.scipy.org/doc/numpy/reference/arrays.scalars.html#arrays-scalars-built-in for possible values	'f'
NEMOH_COMPLEX	Represents the complex type to use when performing computations. It should be a valid numpy complex type. See http://docs.scipy.org/doc/numpy/reference/arrays.scalars.html#arrays-scalars-built-in for possible values	'F'
MESH_TEC_FILE	The path to the file where to save the mesh tec file	No need to change. The default value is fine.
FK_FORCE_TEC_FILE	The path to the froudkrylov force data in tec format	No need to change. The default value is fine.
RADIATION_COEFFICIENTS_TEC_FILE	The path to the file where to save the added mass and damping forces for the radiation problems in tec format.	No need to change. The default value is fine.

Property	Definition	Example
DIFFRACTION_FORCE_TEC_FILE	The path to the file where to save the diffraction force for the diffraction problems in tec format.	No need to change. The default value is fine.
EXCITATION_FORCE_TEC_FILE	The path to the file where to save the the excitation force for the diffraction problems in tec format.	No need to change. The default value is fine.
IRF_TEC_FILE	The path to the file where to save the IRF tec file	No need to change. The default value is fine.
WAVE_FIELD_TEC_FILE	The path to the file where to save the wave field tec file	No need to change. The default value is fine.

4. Implementation details

The references are listed in section 9.

The main code for the fast influence coefficient is computed here
"$NEMOH_FORTRAN/Solver/Core/COMPUTE_INFLUENCE_ODE.f90"

Typically the regular part of the integral for the infinite case is computed using the ODE of equation 11 of R2. The double integral is performed by multiplying the area of the panel by the value of the green function (or it's derivative) at the centroid of the panel.

The paper R2 only gives the green function ODE. It does not give an ODE for the derivatives of the green function. And those are needed to completely compute the influence coefficients.

We have derived them as detailed in GreenFunctionDerivativeODE.pdf.
Notations are similar to R2 and R3. Note that there is a slight mistake in R2 (not affecting the final result). The intermediate step (needed to derive ODE for the derivative), equation (6) of R2 is not correct.
In the right hand side expression, in the first line (the one with Dirac function), the first term (the one containing the third derivative of F) should be multiplied by 4. Also, in the line before the last one (the line containing the second order derivative of the Dirac function), the first term should be the first derivative of F and not F.

The rankine part is computed according to R1 using equations 3.10 and 2.14 respectively for the source and dipole influence coefficients

5. Deployment Instructions

5.1. Generic Instructions

5.1.1. Install a Fortran and C/C++ compiler which support OpenMP (Currently gcc and ifort are supported)
5.1.2. Install Python 2.7

5.1.3. Install pip
5.1.4. Install CMake version greater or equal to 2.8
5.1.5. Install Blas and Lapack and make sure there are in the library search paths
5.1.6. Install hdf5 libraries version greater or equal to 1.8.11 and make sure there are in the library search path

5.1.7. Compile the Fortran version of Nemoh Solver:
  5.1.7.1. Create a build directory $FORTRAN_BUILD different from $NEMOH_FORTRAN
  5.1.7.2. Go to $FORTRAN_BUILD folder.
  5.1.7.3. Delete the file CMakeCache.txt and the directory CMakeFiles if it exists
  5.1.7.4. Run the command cmake
  5.1.7.5. Run make. The Nemoh library will be created

5.1.8. Compile the Nemoh python against the Nemoh Fortran
  5.1.8.1. Go to $NEMOH_PYTHON
  5.1.8.2. Install the python module prerequisites pip install -r requirements.txt
  5.1.8.3. Make sure the $FORTRAN_BUILD is in the library search paths for compilation and for linking
  5.1.8.4. Run python setup.py build_ext --inplace

5.2. Linux Instructions with Ubuntu commands

(If you are not using Ubuntu, you should be able to use your distribution package manager to install equivalent commands)

5.2.1. Install GFortran and gcc by running: sudo apt-get install build-essential gfortran gcc

5.2.2. Install cmake by running sudo apt-get install cmake

5.2.3. Install Blas and Lapack and make sure there are in the library search paths by running sudo apt-get install liblapack-dev libblas-dev

5.2.4. Install python 2.7, hdf5 libraries, and the nemoh python module requirements. To do so, we just need to install Anaconda:
  5.2.4.1. Download Anaconda >= 2.1.0 from http://continuum.io/downloads .
  For linux 64 bits the direct link is (with no space) http://09c8d0b2229f813c1b93-c95ac804525aac4b6dba79b00b39d1d3.r79.cf1.rackcdn.com/Anaconda-2.1.0-Linux-x86_64.sh
  5.2.4.2. Install Anaconda by running bash Anaconda-2.1.0-Linux-x86_64.sh
  5.2.4.3. When prompted, accept to add it's path to your ~/.bashrc.
  5.2.4.4. Make sure the python version you are using is the one from Anaconda by logout then login or by running source ~/.bashrc
  5.2.4.5. If successful, when you run python --version you should see something like **Python 2.7.8 :: Anaconda 2.1.0 (64-bit)**

5.2.5. Compile the Nemoh Fortran
  5.2.5.1. Create a build directory $FORTRAN_BUILD different from $NEMOH_FORTRAN
  5.2.5.2. Go to $FORTRAN_BUILD folder by running cd $FORTRAN_BUILD .
  5.2.5.3. Delete the file CMakeCache.txt and the directory CMakeFiles if it exists by running rm -rf CMakeCache.txt CMakeFiles/
  5.2.5.4. Run cmake -DCMAKE_Fortran_COMPILER="gfortran" $NEMOH_FORTRAN to generate the Makefiles
  5.2.5.5. Run make to build the library

5.2.5.6. The library libnemoh.so will be created

5.2.6. Compile the nemoh python against the nemoh Fortran
5.2.6.1. Go to $NEMOH_PYTHON/nemoh
5.2.6.2. Make sure the $FORTRAN_BUILD is in the library search paths for compilation and for linking by running:
export LD_LIBRARY_PATH=$FORTRAN_BUILD
export LDFLAGS="-L$FORTRAN_BUILD"
5.2.6.3. Run python setup.py build_ext --inplace to build the python module in place

5.3. Windows Instructions

5.3.1. *Install MinGW 4.8.1*
5.3.1.1. You should install posix threads MinGW from
http://sourceforge.net/projects/MinGWbuilds/files/host-windows/releases

The 64 bits is located at http://sourceforge.net/projects/MinGWbuilds/files/host-windows/releases/4.8.1/64-bit/threads-posix/sjlj/x64-4.8.1-release-posix-sjlj-rev5.7z/download

The 32 bits is located at http://sourceforge.net/projects/MinGWbuilds/files/host-windows/releases/4.8.1/32-bit/threads-posix/sjlj/x32-4.8.1-release-posix-sjlj-rev5.7z/download

5.3.1.2. Download the binaries for your platform and extract it somewhere. By default the 64 bits get extracted in a directory named "MinGW64". Let's call this directory **$MINGW_ROOT**

5.3.1.3. Now add the full path to the folder **$MINGW_ROOT\bin** and **$MINGW_ROOT\lib** to your Path. Make sure those directories are at the left most (the beginning) of the Path. See **Setting Path on Windows** sub section for more information

5.3.2. Install CMake 2.8
5.3.2.1. Download and install cmake from http://www.cmake.org/files/v2.8/cmake-2.8.12.2-win32-x86.exe
5.3.2.2. Choose to add Cmake to the path for all users. By default Cmake doesn't put the path at the beginning.
So, you need to make sure the cmake path is at the beginning of your path. It is by default " C:\Program Files (x86)\CMake 2.8\bin". See **Setting Path on Windows** sub section for more information

5.3.3. Install Lapack and Blas
Download and Install lapack and blas from http://icl.cs.utk.edu/lapack-for-windows/lapack/#libraries Choose the dll libraries for MinGW

For example, the 64 bits blas is http://icl.cs.utk.edu/lapack-for-windows/libraries/VisualStudio/3.5.0/Dynamic-MINGW/Win64/libblas.dll
And the 64 bits lapack is
http://icl.cs.utk.edu/lapack-for-windows/libraries/VisualStudio/3.5.0/Dynamic-MINGW/Win64/liblapack.dll

5.3.3.1. Copy them to **$MINGW_ROOT\lib** (the lib directory inside MinGW installation root)

5.3.4. Install Anaconda >= 2.1.0

5.3.4.1. Download and install Anaconda Windows version greater or equal to 2.1.0 from http://continuum.io/downloads . *The 64 bits Windows version is located at* http://09c8d0b2229f813c1b93-c95ac804525aac4b6dba79b00b39d1d3.r79.cf1.rackcdn.com/Anaconda-2.1.0-Windows-x86_64.exe

5.3.4.2. When installing accept adding anaconda to the path and using it's python version as the default python.
By default Anaconda would not put it's path to the beginning of the Windows Path.

You need to move the anaconda paths to the beginning of the Path list.
See **Setting Path on Windows** sub section for more information

For me the paths were C:\Users\yedtoss\Anaconda (the most important) and C:\Users\yedtoss\Anaconda\Scripts. You should replace C:\Users\yedtoss\Anaconda by the location where you install Anaconda

5.3.5. *Compile the Nemoh Fortran*

5.3.5.1. Start Powershell (Or windows cmd if you prefer it)
Make sure that all paths were correctly set. If not then you should close Powershell/Cmd, set the path and reopen it. Basically run python --version, cmake --version, gfortran --version and verify that they come from the one you just installed

5.3.5.2. Create a build directory $FORTRAN_BUILD different from $NEMOH_FORTRAN

5.3.5.3. Go to $FORTRAN_BUILD folder.

5.3.5.4. Delete the file CMakeCache.txt and the directory CMakeFiles if it exists *or better make sure* $FORTRAN_BUILD is empty

5.3.5.5. Run *cmake -DCMAKE_Fortran_COMPILER="gfortran" "*$NEMOH_FORTRAN**"** -G "MinGW Makefiles"

Please note the "" surrounding $NEMOH_FORTRAN. You need it even if the directory does not contain space. Make sure **"**$NEMOH_FORTRAN" is a full path to avoid any cmake bug

5.3.5.6. Run mingw32-make and you will get libnemoh.dll and libnemoh.dll.a

5.3.5.7. Copy both generated file to **$MINGW_ROOT\lib**

5.3.6. Compile the nemoh python against the nemoh Fortran

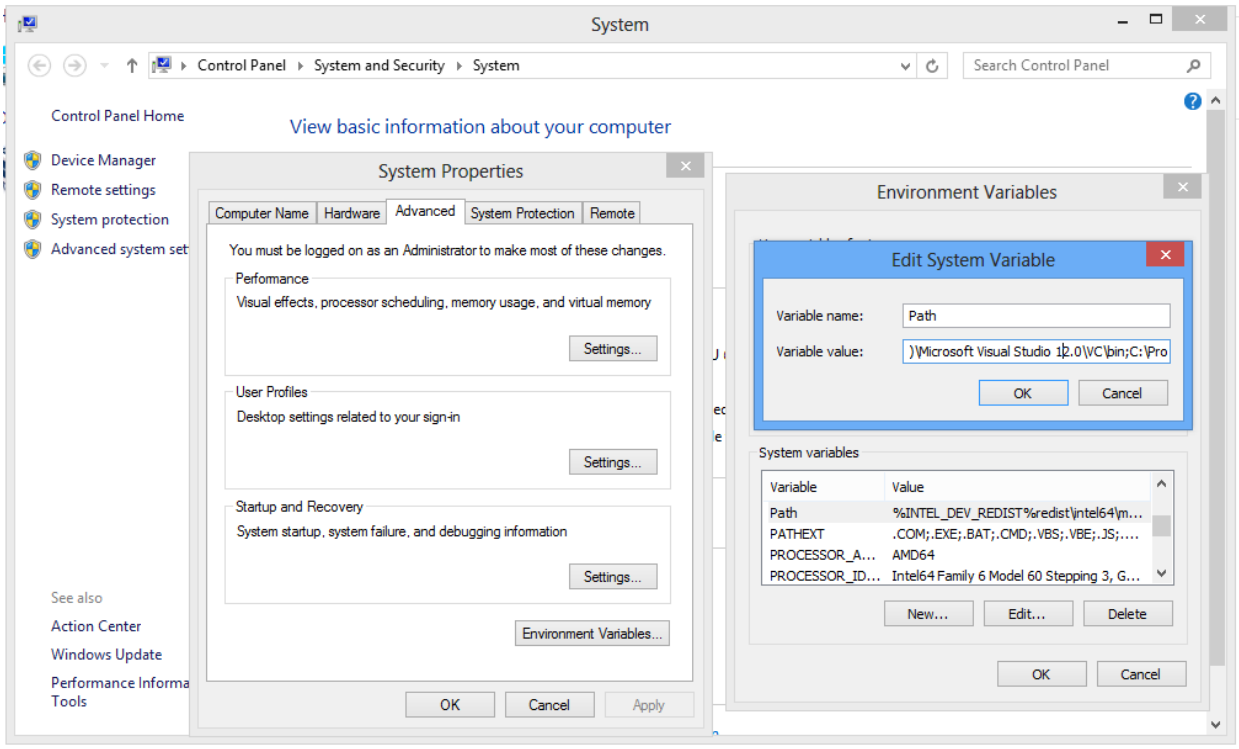
5.3.6.1. Go to $NEMOH_PYTHON\nemoh

5.3.6.2. Run python setup.py build_ext --inplace

5.3.7. **Setting Path on Windows**

You need to go to Computer → Right click and choose Properties → Advanced System Settings → Advanced Tabs → Environment Variables → Look for path.

A screenshot



Note that when setting the path, you need to separate the different directories by **;** Also make sure your new directory is not at the end of the list but at the beginning because Windows read the environment from left to right.

5.4. MAC OS X Instructions

We will use homebrew to install most software

5.4.1. Install brew: ruby -e "$(curl -fsSL https://raw.githubusercontent.com/Homebrew/install/master/install)"
(If you did not have XCode Command Line Tools, it will request it, install it and when done press enter on the terminal)

5.4.2. Run brew doctor

5.4.3. Install gcc and gfortran brew install gcc You can ignore any warning about multilib. It won't affect us

5.4.4. Install cmake brew install cmake

5.4.5. Download and Install anaconda from http://continuum.io/downloads
You can get the 64 bits version from http://09c8d0b2229f813c1b93-c95ac804525aac4b6dba79b00b39d1d3.r79.cf1.rackcdn.com/Anaconda-2.1.0-MacOSX-x86_64.pkg
We will export anaconda bin to the Path before compiling and using the nemoh python module

5.4.6. *Compile the Nemoh Fortran*
- 5.4.6.1. Create a build directory $FORTRAN_BUILD different from $NEMOH_FORTRAN
- 5.4.6.2. Go to $FORTRAN_BUILD folder cd $FORTRAN_BUILD .
- 5.4.6.3. Delete the file CMakeCache.txt and the directory CMakeFiles if it exists *rm -rf CMakeCache.txt CMakeFiles/*
- 5.4.6.4. Run *cmake -DCMAKE_Fortran_COMPILER="gfortran"* $NEMOH_FORTRAN
- 5.4.6.5. *Generate nemoh Fortran library by running make*
  The library libnemoh.dylib will be created
  (If you get a warning about cmake policy ignore it)

5.4.7. Compile the nemoh python against the nemoh Fortran
- 5.4.7.1. Go to $NEMOH_PYTHON/nemoh
- 5.4.7.2. Make sure you are using python from Anaconda
  By running export PATH=/Users/tcs/anaconda/bin:$PATH
  Replace /Users/tcs/anaconda/bin according to the location where anaconda was installed
- 5.4.7.3. Make sure the $FORTRAN_BUILD is in the library search paths for compilation and for linking by running
  export LD_LIBRARY_PATH=$FORTRAN_BUILD
  export LDFLAGS="-L$FORTRAN_BUILD*"*
- 5.4.7.4. Run python setup.py build_ext --inplace

Note that in the above process we did not explicitly install lapack or blas libraries. This is because it is implicitly installed with brew (XCode Command Line Tools). If for some reason you receive an error when linking against lapack or blas you can install a custom version by running brew install https://raw.githubusercontent.com/Homebrew/homebrew-dupes/master/lapack.rb

Also note that the Intel Fortran Compiler (ifort) is fully supported on all three platforms. It comes bundled with lapack and blas so If you choose it, you won't need them.

Installing VMTK (Optional, you can skip)

VMTK is used by $NEMOH_PYTHON/nemoh/export_tec.py to export the generated .tec files to other format. To install it for Mac, Windows or Linux follow instructions at
http://www.vmtk.org/documentation/installation.html
Note that unless you are using the .egg for Anaconda (Windows only), you should not use it with the python from Anaconda. More specifically, on Linux and Mac you have to use it with the built-in python when installing or using it.

6. Starting

You need to setup all environment variables as described in the deployment instructions.

You should also configure the application as described in the configuration section
Enter the directory $NEMOH_PYTHON/nemoh/
Run *python preprocessor.py* to run the preprocessor
Then run the solver with *python solver.py*
Finally run the post processor with *python postprocessor.py*

7. Verification

Setup your environment using the deployment instructions.
Then run the tools by following the Starting section

By default, the cylinder example has been configured. You can run other example by modifying the configuration. You can find additional cases files in $NEMOH_FORTRAN/Verification folder
The hdf5 file db.hdf5 will be generated.

You can visualize it with HDFView from http://www.hdfgroup.org/products/java/release/download.html
It has a version for Windows, MAC and Linux

For example, to install the Ubuntu 64 bits:

- Download http://www.hdfgroup.org/ftp/HDF5/hdf-java/current/bin/HDFView-2.10.1-centos5-static64.tar.gz
- Extract it to /tmp so that you have /tmp/HDFView-2.10.1-Linux, then locate the file hdfview.sh inside it. It should be located at /tmp/HDFView-2.10.1-Linux/HDF_Group/HDFView/2.10.1/bin/hdfview.sh
- Open the file hdfview.sh and set INSTALLDIR to ■■
- Enter the bin directory (/tmp/HDFView-2.10.1-Linux/HDF_Group/HDFView/2.10.1/bin)
- Make sure you have java from Sun, JRE is enough. You can use JRE 6 or JRE 7
- Run bash hdfview.sh

Then open the hdf5 file (Click File → Open)

Enter the directory $NEMOH_PYTHON/nemoh/
Run *python preprocessor.py* to run the preprocessor
Then run the solver with *python solver.py*
Finally run the post processor with *python postprocessor.py*

Ignore the warning of the type "Warning: normal vector of panel 14 points towards the x axis". It is caused by the input mesh used.

The default example for test is $NEMOH_PYTHON/test_files/influence_ode

SPEED VERIFICATION

Basically you need to run the solver using the ODE influence coefficients method and without it. Then you should compare the speed.

There is a python script provided for your convenience in **$NEMOH_PYTHON/test_files/nemohstat.py.** You can use it to compare the speed of the two methods. Here are the steps to use it

- make sure USE_ODE_INFLUENCE_COEFFICIENTS is set to True in **$NEMOH_PYTHON/nemoh/settings.py.**

- Change directory to $NEMOH_PYTHON/nemoh and make sure environment variables are correctly set as explained in deployment instructions

- Run python $NEMOH_PYTHON/test_files/nemohstat.py "python preprocessor.py" "python solver.py" 3

(Here 3 indicates the number of times you want to run the preprocessor and solver. You can increase it if you want)
The preprocessor and solver will be run 3 times and at the end we will get the best cpu time.
In our case it was 12.6705260277 seconds

- Set USE_ODE_INFLUENCE_COEFFICIENTS to False

- Run python $NEMOH_PYTHON/test_files/nemohstat.py "python preprocessor.py" "python solver.py" 3
- Check the result cpu time. In our case it was 16.6041529179 seconds

As you can see, the new influence coefficients method via ODE is faster than the old method

Result: OLD Code : 16.6041529179 seconds
New Code: 12.6705260277 seconds

ACCURACY VERIFICATION

Basically you need to run the solver using the ODE influence coefficients method and without it. Then you should compare the results.

According to reference R2, the accuracy of the new method of computing influence coefficients using ODE should match the method used in AQUADYN and thus by extension in Nemoh too.

The main results to check are the potential, the forces, and the Froude Krylov forces (fk_forces).
In the hdf5 output file you can check them in results/potential, results/forces, results/fk_forces respectively.

For your convenience, we have provided a python script in **$NEMOH_PYTHON/test_files/compare.py** to compute the MAE score between number in two text files. Here are the step to check the accuracy.

- make sure USE_ODE_INFLUENCE_COEFFICIENTS is set to True in $NEMOH_PYTHON/nemoh/settings.py

- Run the preprocessor then the solver.

- Open $NEMOH_PYTHON/test_files/influence_ode/db.hdf5 with hdfview

- Then export the table results/forces to a text file in $NEMOH_PYTHON/test_files/influence_ode/comp/forces_new.txt (To do that, double-click the name in the left panel. A new window will be opened, click Table → Export Data to Text File and choose the correct location)

- Export also results/potential and results/fk_forces respectively in

$NEMOH_PYTHON/test_files/influence_ode/comp/potential_new.txt and
$NEMOH_PYTHON/test_files/influence_ode/comp/fk_forces_new.txt

- Set USE_ODE_INFLUENCE_COEFFICIENTS to False and repeat the previous steps replacing the text file where to save as $NEMOH_PYTHON/test_files/influence_ode/comp/forces_old.txt $NEMOH_PYTHON/test_files/influence_ode/comp/potential_old.txt and $NEMOH_PYTHON/test_files/influence_ode/comp/fk_forces_old.txt respectively for results/forces, results/potential and results/fk_forces.

- Change directory to $NEMOH_PYTHON/test_files/influence_ode/comp

- Run $NEMOH_PYTHON/test_files/compare.py potential_old.txt potential_new.txt and check the MAE score you get. It should be near 0

- Rerun the previous command with the other files

For you convenience we have placed our exported data in $NEMOH_PYTHON/test_files/influence_ode/comp. Also you can visualize the hdf5 file of the old method of computing influence coefficients in $NEMOH_PYTHON/test_files/influence_ode/db_old.hdf5. The new one is available in $NEMOH_PYTHON/test_files/influence_ode/db.hdf5.
All MAE in our tests gave 0.0 confirming the match between new and old method.

RESULT: MAE (Mean Absolute Error) is 0.0 for potential, forces and fk_forces

8. Limitations of the new method of computing influence coefficients

The new method to compute the influence coefficients does not support the technique for symmetry in the body as described in R5. This is mainly because the paper R2 does not specify how computation can be made faster in case of symmetry.

To run your problem containing a symmetry in the mesh, disable the symmetry switch by setting the second number in the mesh file to 0 before running the preprocessor. Alternatively you can also set the second number in input/bodies/body1/mesh of the input hdf5 file to 0. You should do this for all bodies of your problem.

A message error will be given and program will stop if an attempt to use the new method in such case.

Finally the new method is not supported for the finite depth case. This is because in paper of reference R2, there is no ODE given for the finite depth case. We can read “The extension of these results to the

case of finite water depth is still an open challenge.”
In the finite case the old method of computing the influence coefficient will always be used.

9. References

R1 **Distributions of sources and normal dipoles over a quadrilateral panel** (Available in another contest (Dipoles, request permission) document paper 2 http://community.topcoder.com/tc?module=DownloadDocument&docid=27516374)

R2. **A second order Ordinary Differential Equation for the frequency domain Green function.** http://www.iwwwfb.org/Abstracts/iwwwfb28/iwwwfb28_12.pdf

R3. **An ordinary differential equation for the Green function of time-domain free-surface hydrodynamics** https://www.deepdyve.com/lp/springer-journal/an-ordinary-differential-equation-for-the-green-function-of-time-0CHiS7fFO1 You can register for a free 2 weeks to access it.

R4. **Amélioration des performances des codes de calcul de diffraction-radiation au premier ordre** http://lheea.ec-nantes.fr/lib/exe/fetch.php/emo/nemoh/delhommeau_papier052jh.pdf

R5. **Les problemes de diffraction-radiation et de resistance de vagues : etude theorique et resolution numerique par la methode des singularites** http://lheea.ec-nantes.fr/lib/exe/fetch.php/emo/nemoh/thesedsgd010787.pdf

10. Resource Contact List

Name	Resource Email
yedtoss	