**K_aug Installation Manual for Windows (2023) by Gul Hameed (University of Surrey)**

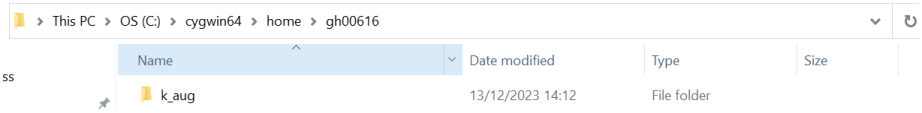
k_aug is a package for calculating Karush-Kuhn-Tucker (KKT) matrix sensitivity and reduced hessian computation. It was developed by David M. Thierry at Carnegie Mellon University in collaboration with Prof Lorenz T. Biegler at the Centre for Advanced Process Decision-making (CAPD). k_aug is compatible with Pyomo and AMPL via ASL and its main functionality can be accessed through suffixes. k_aug assumes that the user is using the IPOPT (interior point optimizer) solver (Waechter and Biegler, 2006), which is used for large-scale non-linear programming. IPOPT is available for free from https://projects.coin-or.org/Ipopt. To use k_aug, IPOPT needs to be installed and added to the system's path. A detailed installation guide for IPOPT is available at the previous link. This guide is intended to assist users installing k_aug on Windows systems.

1. First, download Cygwin from https://www.cygwin.com/. Cygwin is an environment that mimics a UNIX-like system and allows the user to recompile and run programs on Windows without having to modify the source code. When installing Cygwin, during the package download section, ensure that the following list of requirements are included.
    - cmake
    - gcc-core
    - gcc-gfortran (gfortran)
    - gcc-g++
    - git
    - make
    - wget
    - zlib-devel
    - patch
    - openblas
    - lapack-devel
    - pkg-config
    - numpy
    - libgfortran
    - binutils
    - diffutils
    - grep
    - metis

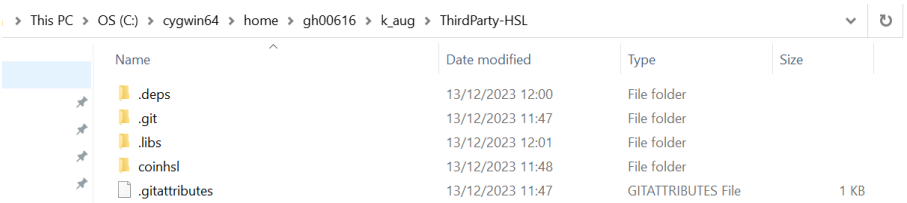
    If you are unable to find the exact packages, install the ones with identical names. Make sure to check the box that asks to generate Cygwin command icon on either desktop or in start menu, else you should open Cygwin (when required) by going into C:\cygwin64. Try to include other packages as well, (the list mentioned previously, worked for me) which you think, you may need for installing the coin-or tools and k_aug.
2. Then, download the .zip from https://github.com/dthierry/k_aug under "Clone or download". Place this folder into the Cygwin home folder, C:\cygwin64\home\YOURUSERNAME (it is gh00616 for me)\ and unzip. Next, launch the Cygwin command line and navigate to the appropriate folder using:
    `cd k_aug`
    Instead of downloading k_aug from GitHub and then copy-pasting (as mentioned previously), you can launch Cygwin Terminal (i.e., command line) from desktop or start menu and use the following command lines (one by one) to start setting up k_aug.
    `git clone https://github.com/dthierry/k_aug.git`

cd k_aug

k_aug will be inside Cygwin directory as shown in the figure given next.




3. K_aug requires coin-or libraries (coinasl, coinhsl and coinmetis), which can be downloaded installed from coin-or tools available online at GitHub.
   Now in command line of Cygwin, you are inside k_aug folder (by using command: 'cd k_aug').
   To install ASL coin-or tool, use the following commands (one by one) in Cygwin (inside k_aug folder).
   git clone https://github.com/coin-or-tools/ThirdParty-ASL.git
   cd ThirdParty-ASL
   ./get.ASL
   ./configure
   make
   make install
   cd ..
4. To install HSL coin-or tool, use the Cygwin commands given next (inside k_aug folder).
   git clone https://github.com/coin-or-tools/ThirdParty-HSL.git
   cd ThirdParty-HSL
   You have already obtained licence for IPOPT from http://www.hsl.rl.ac.uk/ipopt/, and you have a file like 'coinhsl-2015.06.03' (which was downloaded after obtaining IPOPT licence). Rename this file as 'coinhsl', and copy-paste it inside the ThirdParty-HSL folder found inside k_aug directory. See the figure given next for reference.



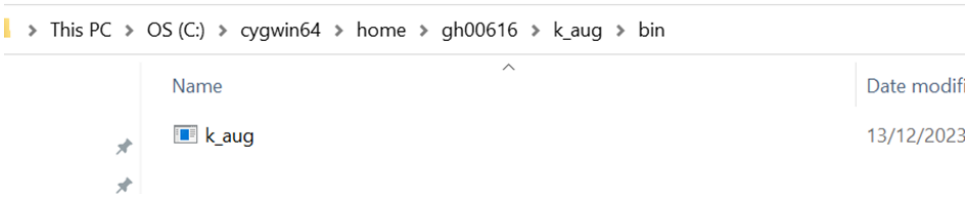

   Inside ThirdParty-HSL folder (and not inside coinhsl folder!), perform the following commands.
   ./configure
   Make
   make install
   cd ..
5. To install Metis coin-or tool inside k_aug folder, use the following commands (one by one) in Cygwin.
   git clone https://github.com/coin-or-tools/ThirdParty-Metis.git
   cd ThirdParty-Metis
   ./get.Metis
   ./configure
   make
   make install
   cd ..
6. To install Mumps coin-or tool, use the Cygwin commands given next (inside k_aug folder).
   git clone https://github.com/coin-or-tools/ThirdParty-Mumps.git
   cd ThirdParty-Mumps
   ./get.Mumps
   ./configure

make
make install
cd ..

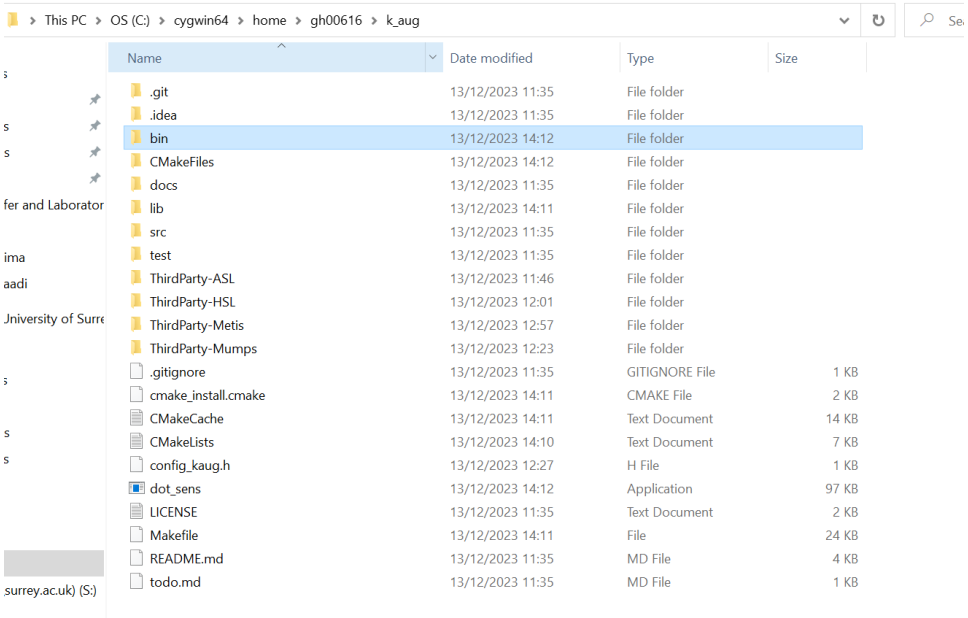
7. Put the location of gfortran in the line 102 of the CMakeLists.txt (can be found inside k_aug folder) after HINTS. I found the file location of gfortran inside gcc by myself, and edited line 102 of this text file. Figure is given next for your reference.

```
find_library(GFORTRAN NAMES gfortran HINTS /lib/gcc/x86_64-pc-cygwin/11 REQUIRED)  #: Sometimes on macOS /usr/local/opt/gcc/lib/gcc/10
#: Sometimes on linux /usr/lib/gcc/x86_64-linux-gnu/X otherwise /usr/lib/gcc/arch-os/VERSION
```

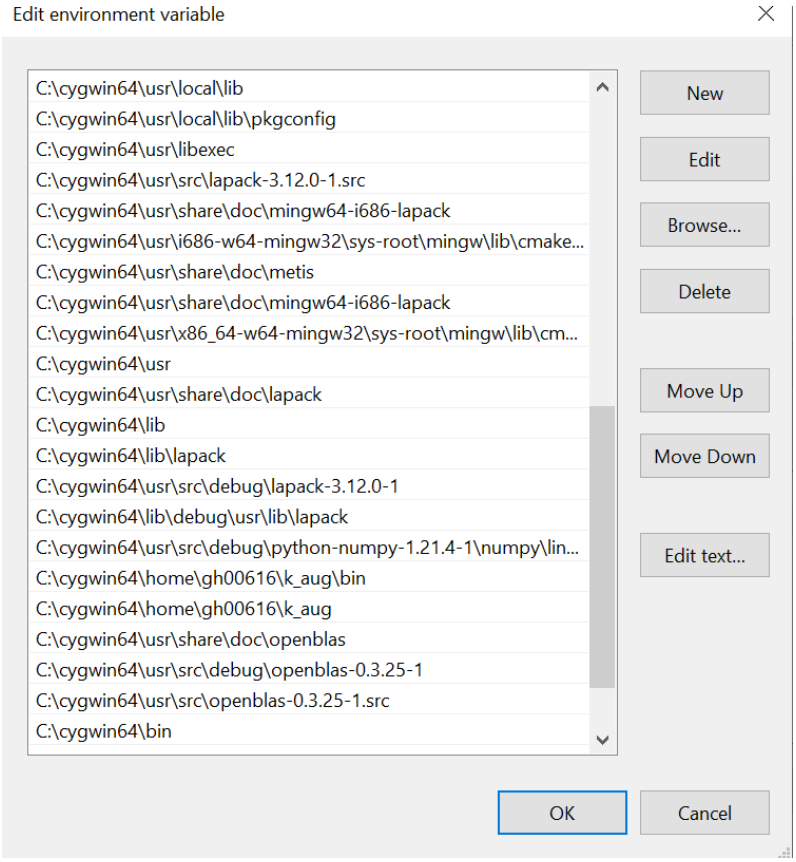
8. Now at the root directory of k_aug, use following Cygwin command.
   cmake CMakeLists.txt
   If you are getting error, possibly you must change some directories or names of files inside CMakeLists.txt file. After editing, run the previous command again.
   If previous command runs successfully, then perform the next command in the same (k_aug) folder.
   Make
   If 'make' command is successful, you will be able to find k_aug executable inside bin of k_aug directory (figure is attached for reference).




k_aug directory (and third-party packages inside it) will be as shown in the next figure by this point.




9. Add the LAPACK library directory to the PATH (Cygwin typically /usr/lib/lapack, as well the libcoinX.dll.a (X=asl,hsl,metis) files (typically located at /usr/local/lib/).
10. If you execute k_aug command in command prompt and you get error like '.dll files are missing', search/find the specific file (inside Cygwin folder) and add it to path in environment variables. You might have to have to do this procedure for various missing .dll files. You can see my path folder as shown in the figure given next.




11. Finally, on successful installation of k_aug, you will get the following message when you execute k_aug on some command prompt.

```
(TRF) C:\Users\gh00616>k_aug
No stub!
usage: k_aug [options] stub [-AMPL] [<assignment> ...]

Options:
        --  {end of options}
        -=  {show name= possibilities}
        -?  {show usage}
        -bf {read boundsfile f}
        -e  {suppress echoing of assignments}
        -of {write .sol file to file f}
        -s  {write .sol file (without -AMPL)}
        -v  {just show version}

(TRF) C:\Users\gh00616>
```

12. Now, we are ready to use k_aug!