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CondorNTM User's Guide

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Introduction

CondorNTM is similar to RunNTM in that it calculates a series of normal (or extreme) turbulence model simulations consistent with the International Electrotechnical Commission (IEC) design load cases [1]. The major difference is that it employs the computational grid software Condor [2], which was developed by the University of Wisconsin. The advantage of using Condor is that many different computers connected on the network can be used simultaneously to calculate the various design load cases required by the IEC standard. This results in a large increase in computational resources proportional to the number of computers installed on the Condor grid.

Details about Condor and installing it on a computer network can be found at the Condor Project Web site [2]. The software can be downloaded at no charge and is available for several different operating systems. No additional hardware has to be purchased, and the software works well on typical desktop machines.

As an example of Condor's power, the author was able to run an entire year's worth of wind turbine simulations (more than 52,000 10-minute sims) in 26 days using a cluster of 30 processors. On a dedicated single dual-processor machine with an average simulation time of 30 minutes, that task would have taken a year and a half to complete. Condor thus increased productivity by more than 20 times.

Software

The software is divided in two different pieces: **CondorNTM** and **PostCondorNTM**. The reason for this is that Condor does not perform simulations in a consecutive manner; therefore, an analysis of turbine simulations can take place only after all the simulations are complete. The Perl script CondorNTM creates input files and directories and submits simulation tasks to the Condor network, using the simulation codes TurbSim and FAST. After all the simulations are complete, PostCondorNTM organizes the simulation output files and analyzes them using Crunch according to the user's preferences.

Retrieving Files from the Archive

You can download the CondorNTM archive from NREL's design code Web site [3]. The file name will be something like this: **condorntm_v100.exe.** You can create a folder for the application, copy the archive to the folder, and double-click to expand the contents.

Distributed Files

The files contained in the CondorNTM archive include these:

ArcFiles.txt	The list of files written to the archive
ChangeLog.txt	The list of changes to the CondorNTM Perl script
CondorNTM.doc	This user's manual in Word format
CondorNTM.pdf	This user's manual in PDF format
CondorNTM.pl	The execution Perl script
PostCondorNTM.pl	The analysis Perl script
WP1.5\WindPact.pit	The pitch control settings for the WindPact turbine
WP1.5\WindPact1.cru	The first part of the Crunch analysis file
WP1.5\WindPact1.fst	The first part of the FAST input file for the WindPact turbine
WP1.5\WindPact2.fst	The second part of the FAST input file for the WindPact turbine
WP1.5\WindPact_AeroDyn.ipt	The AeroDyn input file for the WindPact turbine
WP1.5\WindPact_Blade.dat	The blade data input file for the WindPact turbine
WP1.5\WindPact_Tower.dat	The tower data input file for the WindPact turbine
WP1.5\wind\TurbSim1.inp	The first part of the TurbSim input file
WP1.5\wind\TurbSim2.inp	The second part of the TurbSim input file
WP1.5\aero*.dat	The airfoil data files for the WindPact turbine

Installing Associated Software

If you have not already done so, you will need to install TurbSim, FAST, Crunch, a Perl intrepreter, and Condor. You can get TurbSim, FAST, and Crunch from our Web site [3]. You should install them so that they can run from any folder [4], but you can specify their locations in the Perl script. You can download a freeware Perl interpreter from ActiveState [5]. It should also be installed so that it can be run from any folder. The examples below assume that you can invoke the Perl interpreter by entering **perl** or **filename.pl** at a command prompt. If you use another name, substitute that name into the example below. You can download and install Condor from the Condor project home page [2], as mentioned earlier.

Modifying CondorNTM

You will need to modify the Perl script before you can run it on your PC. Edit the file named **CondorNTM.pl** with your favorite editor. You will need to change the variables $wind_sim_location, $fast_location, $wind_sim, and $fast_sim. Set them so they point to the TurbSim and FAST executables you installed earlier. Two other variables you'll have to change for your computer are $wind_dir and $fast_dir. These represent the directory where TurbSim and FAST input files can be found. After the archive is installed, the FAST input files should be located in **install_directory\ CondorNTM\WP1.5** and the TurbSim input files in **…\WP1.5\wind**.

For this example, I've set the number of wind speeds to 21 and the cases per wind speed to 2 each for a total of 42 runs. This will take some time to run on your Condor network, depending on the number of processors you have installed and their availability. Each run takes about 15 minutes to execute on a 3.2 GHz PC. For a cluster with 10 PCs, the 42 runs should take a little over an hour. When creating a loads document, you should run at least 5 wind speeds, and we recommend that you run 10-20. At least 3 should be at or above rated wind speed. We also recommend 100 turbulence seeds, and a minimum of 10 seeds. This produces as many as 2000 10-minute simulations. That task would take a cluster of 10 PCs about two days. An advantage of the script is that you just have to start it up and let it run. Condor automatically dispatches jobs to available machines and retrieves their outputs. If you don't have that much time, reduce the number of wind speeds and/or number of cases for each wind speed. To set these numbers, change the $MinWindSpeed, $MaxWinSpeed, $WindSpeedInc and the $NumCases variables.

If you choose to use a simulator other than FAST, you will need to make many more changes to the script. To do that, you will need to know more about Perl. One way to learn Perl is by studying other people's code and modifying it to suit your needs. Staff at NREL also recommended two books (*Programming Perl*, by Larry Wall et al., and *Effective Perl Programming*, by Joseph Hall and Randal Schwartz) to help you learn the language. Modifying the script for another simulator depends on the simulator, so there is no attempt to explain how to do that here. Look for the string **fast** in the script to determine where to start.

Running CondorNTM

Before using CondorNTM, you will want to check the versions of FAST and TurbSim installed on your computer. If they are newer (or much older) than your CondorNTM archive, you may have to make changes to their input files to bring them up to the current versions. The input files created by CondorNTM (**WindPact.fst** and **TurbSim.inp**) state the versions of the programs that they are compatible with at the top of the files.

To test the script, you can use our WindPact 1.5 MW model. Try it first before using your own model with CondorNTM. Open up a command window in the main CondorNTM folder. Simply enter **CondorNTM.pl** at the command prompt. The script will loop through a series of wind speeds and number of cases. Within each double loop, it will create a directory for each run corresponding to the run number, starting with zero, e.g., CondorRun/Run.0/. In each directory, CondorNTM will create a FAST input file, **WindPact.fst**, from the two parts (WindPact1.fst and WindPact2.fst) and the rotor speed for the given wind speed. CondorNTM will also create a wind input file, **TurbSim.inp**, from its two parts (TurbSim1.inp and TurbSim2.inp), including the mean wind speed and turbulence intensity from either the normal turbulence model or the extreme turbulence model, as specified by the IEC standard [1].

CondorNTM also creates the Condor submit file, **WindPact.sub**, which tells Condor which files need to be copied to the execute machine in the network, which operating system can be used, the approximate size of the job, where the error logs are located, and how many different runs are going to be executed. Finally, CondorNTM submits this file to the Condor network and all the jobs are placed in the queue. The status of the jobs can be found using the **condor_q** command at any command prompt from the submitting computer.

When a job is accepted on an execution machine, the batch file **WindPact.bat** is executed. This first runs TurbSim to generate a full-field wind file and then runs FAST to simulate the turbine. The jobs will take some time to run and will not necessarily run in order; they might even be stopped in the middle of a run by the execute machine (e.g., the user of the machine returns), but eventually all jobs should be completed. If the job does not run, the likely reason is that there is a problem with your Condor network, which could require some tweaking. The user manuals at the Condor Project homepage are useful for resolving such issues [2].

After you run the script with the original model, you will need to change the TurbSim and FAST input files to represent your turbine, as well as the CondorNTM file. The TurbSim input files you need to change are **TurbSim1.inp** and **TurbSim2.inp**, which are found in the WP1.5\wind folder. The FAST input files **WindPact1.fst** and **WinPact2.fst** are in the WP1.5 folder. The main CondorNTM file should be modified to include the correct turbine properties (rotor radius, rated wind speed, rated rotor speed, and reference height). The wind turbine design class can also be modified appropriately. Finally, and perhaps most important, the area of CondorNTM that creates the Condor submit file needs to be modified to reflect the correct names and locations of the files sent to the execute machine. Modify all of the **printf** statements that occur after the command **transfer_input_files =** to include all of the files that are necessary to run the simulations. Note that the \ character at the end of the line represents a line continuation, which allows users to add as many files as they would like. You may want to comment out the **condor_submit** command at the end of the file (put a pound sign [#] at the beginning of the line) and inspect the Condor submission file before actually submitting it to the network. If you do mistakenly submit an incorrect set of files, use the command **condor_rm –all** to remove all the jobs submitted.

Modifying PostCondorNTM

When all the jobs from CondorNTM are complete (run **condor_q** to ensure that no jobs are left in the queue), the output from the simulations can be organized and analyzed using the next Perl script, PostCondorNTM. Before you do that, you must modify the file **PostCondorNTM.pl** for your computer. You will need to change the variables $crunch_location and $crunch_sim to point to the Crunch executable installed on your machine. You also need to modify the names of the directories and files so that they are consistent with those of the CondorNTM.pl file. In addition, the wind speed variables must match those of the CondorNTM script.

If you prefer not to analyze the data but would like to use PostCondorNTM to organize your output files, comment out the Crunch execution statement in the middle of PostCondorNTM.pl by putting # at the beginning of the line.

Running PostCondorNTM

Before using PostCondorNTM, please check the version of Crunch you have installed on your computer. If it is newer (or older) than your PostCondorNTM archive, you may have to make changes to the input files to bring them up to the current versions.

First, PostCondorNTM creates five new directories for output and analysis: extremes, fatigue, output, statistics, and wind. Next, it copies the FAST simulation output files and wind simulation output to the output and wind folders, respectively. The name of each file also reflects the mean wind speed, the turbulence model (ETM or NTM), and the random seed integer (or case number) for that wind speed.

After copying the final simulation outputs, a Crunch input file is created based on the file **WindPact1.cru**. Using this input file, Crunch is executed, and summary statistics, fatigue cycles, and peaks over the threshold are calculated for each FAST output file. In the final step, PostCondorNTM moves each of these files to the appropriately named folder.

If you change the output variables in the FAST input file, you will need to modify the Crunch input file to change the channels that are analyzed. You may also want to make other changes to the Crunch input file to meet your analysis needs. After you've done all these things, you can rerun the script.

For a real loads document, you should include other events—especially the discrete wind cases *and* the various fault conditions. To help you do that, you can use the companion script, RunIEC, to generate the discrete wind cases. For fault conditions, you're on your own. If you do this, it will probably make sense to comment out the Crunch call in the Perl script and then run Crunch manually after all cases are run.

References

[1] IEC/TC88, 61400-1 ed. 3, *Wind turbine generator systems-part 1: Safety Requirements*, International Electrotechnical Commission, 2004.
[2] Condor Project home page, http://www.cs.wisc.edu/condor/.
[3] NREL design code Web site, http://wind.nrel.gov/designcodes.
[4] Buhl, M.L., Jr. *Installing NWTC Design Codes on PCs Running Windows NT®.* NREL/EL-500-29384. Golden, CO: National Renewable Energy Laboratory, 2000, 2 pp.
[5] ActiveState Web site, http://www.activestate.com/.

Known Bugs

None.

Caveats

The National Renewable Energy Laboratory (NREL) cannot guarantee the usefulness or accuracy of CondorNTM, which is essentially a beta code. NREL does not have the resources to provide full support for this program. *You may use CondorNTM for evaluation purposes only*.

Acknowledgements

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Feedback

If you have problems with CondorNTM, please contact Pat Moriarty. I will respond as time permits, but please do not expect an immediate response. Please send comments and bug reports here:

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