Open Source Computer Aided Engineering Inititive (OSCAE.Initiative) at Universiti Teknologi Malaysia

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Abstract

Open Source Computer Aided Engineering Initiative (OSCAE.Initiative) is a public statement of principles relating to open source software for Computer Aided Engineering. It aims to promote the use of open source software in engineering discipline with a goal that within the next five years, open source software will become very common tools for conducting CAE analyses. Towards this end, a small OSCAE.Initiative lab to be used for familiarizing and developmental testing of related software packages has been setup at the Marine Technology Centre, Universiti Teknology Malaysia.

This paper describes the infrastructure setup, computing hardware components, multiplatform operating environments and various categories of software packages offered at this lab which has already been identified as a blueprint for another two labs sharing a kindred spirit.

1 Overview

The OSCAE.Initiative lab at Universiti Teknologi Malaysia, is located on the second floor of the Marine Technology Centre (MTC). It was established to promote the use of open source software in engineering discipline with a goal that open source software will become the tools of choice for conducting CAE analyses and simulations.

Currently, the lab provides

- general purpose computing facilities for educational and academic use, and
- specialized (CAE) lab environments, software, and support

for students, researchers and staff of MTC. Access is by terminals throughout the lab. While users are not required to have their own computers, it is recognized that many do, and facilities are provided to transfer data to and from the OSCAE.Initiative systems so that personal computers and workstations at OSCAE.Initiative lab can complement each other.

2 Computing Hardware, Operating Environments & Software

Intel's family of workstation platforms pervades throughout the lab and they are split under two operating system environments—ten of the workstations operate in Ubuntu MATE Linux and three workstations offer the familiar operating environment of Microsoft Windows 10. CAE software on the workstations is categorized into

1. Computational Fluid Dynamics (CFD), and
2. Finite Element Analysis (FEA)

workflow (Geometry Input → Pre-Processing → CFD/FEA Solvers → Post-Processing) streams. Tables 1 and 2 show matrices of open source and commercial software for these two streams.

Table 1: Matrix of CFD Tools

Matrix of Open Source and Commertial CFD Tools							
Geometry Input	FreeCAD	BRL-CAD	VariCAD	Parasolid	Pro-E	Catia	Discrete
Pre-Processing	gmsh	Netgen	Salome	SnappyHexMesh		Pointwise	
CFD Solvers	OpenFOAM		Code_Saturne		Dolfyn	Ansys	Comsol
Post-Processing	ParaView	VisIt	Salome	Tecplot	EnSight	Fieldview	Matlab

Open Source
Commercial

Table 2: Matrix of FEA Tools

Matrix of Open Source and Commertial FEA Tools							
Geometry Input	FreeCAD	BRL-CAD	VariCAD	SolidWorks	Parasolid	Pro-E	Catia
Pre-Processing	gmsh	Salome	Netgen	enGrid	Pointwise		
FEA Solvers	Code_Aster		z88Aurora3		Abaqus	Ansys	Comsol
Post-Processing	Salome	gmsh	VisIt	Tecplot	EnSight	Fieldview	Matlab

Open Source
Commercial

2.1 Linux Workstations

Software on OSCAE.Initiative Linux workstations is installed on the local hard disk and identical on all workstations. CAE tools are customized under a dedicated **CAE Tools** submenu off the **Applications** menu, as shown in Figure 1.

Each of the Linux workstations is currently inaccessible over the Internet from outside UTM. However, remote access from within the Marine Technology Centre is available via Virtual Network Computing (VNC) protocol.

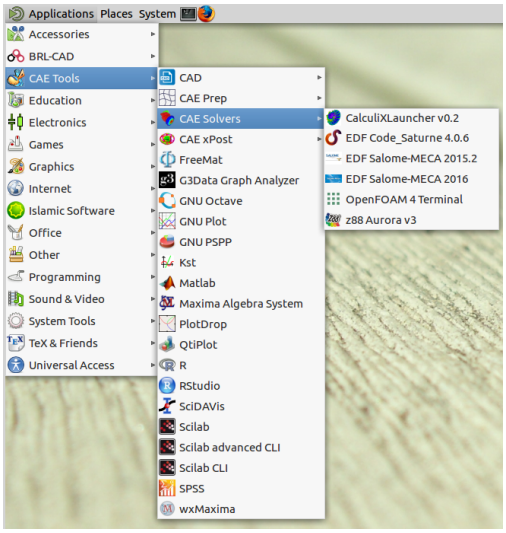

Figure 1: Customized **CAE Tools** submenu.

2.2 Windows Workstations

Unlike the Linux configuration, instead of being customized under a dedicated **CAE Tools** submenu, CAE tools in Windows 10 environment are grouped into a dedicated **CAE** folder and permanently displayed on the Desktop for quick and easy access. This folder contains downstream subfolders of CAE workflow (**CAD**, **CAE_Prep**, **CAD_Solv**, **CAD_xPost**) and links to many other complementary CAE tools, see Figure 2.

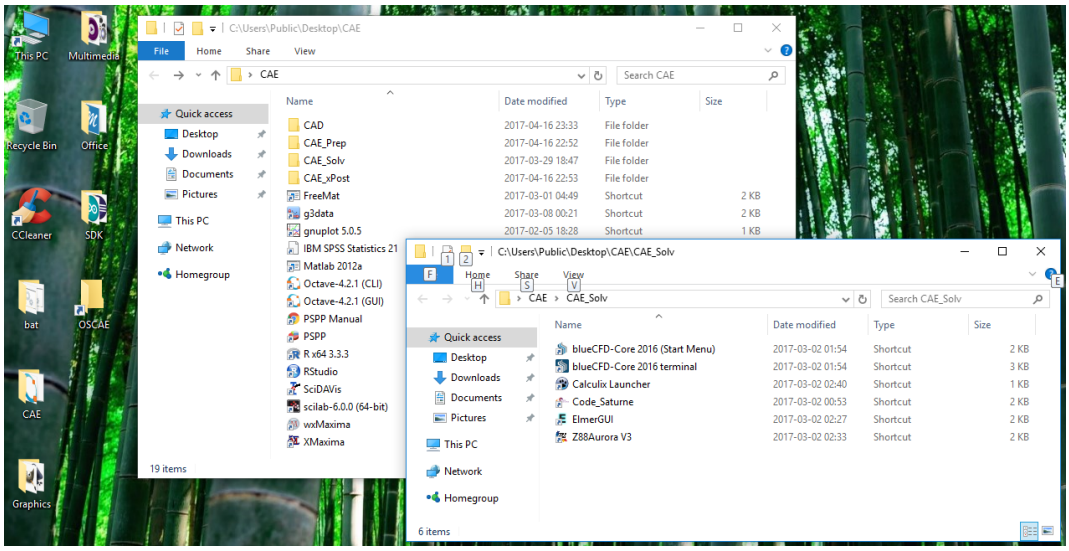

Figure 2: Dedicated **CAE** folder.

Software on all OSCAE.Initiative Windows workstations is installed on the local hard disk, thus each workstation offers a complete dedicated CAE analysis environment.

Table 3 lists the OSCAE tools installed onto both, Linux and Windows, workstations.

Table 3: OSCAE Tools

	Linux	Windows		Linux	Windows
CAD & Graphics			**Software Development Kits**		
Blender	✓	✓	GNU SDK	✓	✓
Luxrender	✓	✓	Oracle JDK	✓	✓
FreeCAD	✓	✓	CodeBlock	✓	✓
BRL-CAD	✓	✓	Eclipse	✓	✓
gCAD3D	✓	✓	Cmake	✓	✓
KiCAD	✓	✓	Perl, Python, Tcl/Tk	✓	✓
QCAD	✓	✓	nano, gedit, geany	✓	✓
CFD & FEA Solvers			**Office Suites & Typesetting**		
OpenFOAM	✓	✓	LibreOffice 5	✓	✓
Code_Saturne	✓	✗	TEX/LATEX	✓	✓
Code_Aster	✓	✓	GanttProject	✓	✓
z88Aurora3	✓	✓	Scribus	✓	✓
Pre-Processors			InkScape	✓	✓
Salome	✓	✓	Calibre	✓	✓
enGrid	✓	✓	DjvuLibre	✓	✓
gmsh	✓	✓	**Multimedia**		
Netgen	✓	✓	mpv+smplayer	✓	✓
MeshLab	✓	✓	vlc	✓	✓
Post-Processors			HandBrake	✓	✓
Salome	✓	✓	mkvtoolnnix	✓	✓
ParaView	✓	✓	audacity	✓	✓
VisIt	✓	✓	Kodi	✓	✗
GNUplot	✓	✓	xine	✓	✗
Mathematics			**Statistics**		
Octave	✓	✓	R	✓	✓
Scilab	✓	✓	RStudio	✓	✓
Maxima	✓	✓	PSPP	✓	✓

3 OSCAE.Initiative–Marine Technology Centre: A Synergy

As an engineering discipline research facility, the OSCAE.Initiatice lab is expected to

- bridge models, simulations, and experiments as an integrative approach to validation in CAE analyses,
- validate simulated solutions to engineering problems by elucidating the interrelations between models, simulations, and experiments,
- allow researchers to perform an extensive set of computer simulations, which are then validated against established experimental results, to come up with quick lookup tables to be used for industrial problem solving.

Meanwhile, there are more than 30 ship hull models which have been model-tested at the Marine

Technology Centre over the last two decades. As MTC is now pursuing an effort to put these models through CFD analysis, OSCAE.Initiative is offering its open source CFD tools to perform the simulations which will subsequently be validated using results from the model testing.

In parallel to this OSCAE workflow study, similar CFD analysis will be put through the commercial codes (Ansys). By the end of this exercise, each hull will have three sets of results:

1. model testing
2. OSCAE (gmsh + OpenFOAM + ParaView) analysis
3. commercial CFD (Ansys) analysis

which will be archived at MTC for future reference and optimization works.

It is much hoped that this synergy between great many experimental works at MTC and low-budget simulations using OSCAE tools will help cut down the cost of R&D and open many other opportunities.

4 OSCAE.Initiative Workshops

The cost effectiveness and open access to the open source codes lead the author to believe that the most attractive possibility to have a real OSCAE "start-to-finish" solution is by testing workflows, each composed of different OSCAE modules, and implementing one that fits exactly with pre-defined engineering processes; this "mix-and-match" calls for more explorations and researches on the integrability of one module with another so that they become a whole. As a corollary of this effort, a pool of experts need to be trained to use a multitude of OSCAE tools; engineers who in turn will provide support to the small and medium sized engineering enterprises with highly robust and cost-effective design and optimization solution.

All OSCAE tools used in the OSCAE.Initiative lab run on Linux-based computing hardware, only very few are not available on Windows platform. OSCAE.Initiative lab has a small team of experienced workshops facilitators and now offers a short list of introductory workshops which are suitable for engineering students or engineers to companies and organizations, see Table 4.

Table 4: OSCAE Workshops

Workshop	OSCAE Tools Used	Duration
Introduction to Linux	Linux	1 day
Typesetting Technical Documents	LaTeX	1 day
Engineering Data Processing and Analysis	g3data, Octave, SciDAVis	1 day
FEA using Code_Aster	Code_Aster, Salome	2 days
CFD using Code_Saturne	Code_Saturne, Salome, ParaView	2 days
Introduction to OpenFOAM	OpenFOAM, gmsh	2 days

Short Linux courses are conducted regularly for the uninitiated. Users already familiar with Windows will be introduced to virtual network computing protocol to seamlessly hook up their Windows PC to the OSCAE system running on Linux in a transparent cross-platform environment.

5 Conclusion

A very simplified view of OSCAE.Initiative lab has been presented. It explains the specific case of a small OSCAE.Initiative lab attached, and in synergistic mode, to a larger research centre. The OSCAE tools being espoused will enable engineers and researchers at MTC to rapidly manifest the results of computer simulations in their ship design and better explore the related physical phenomena without the prohibitive costs.

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