Computational Aircraft Prototype Syntheses

Training Session 8
CFD Analysis: Fun3D/SU2

ESP v1.18

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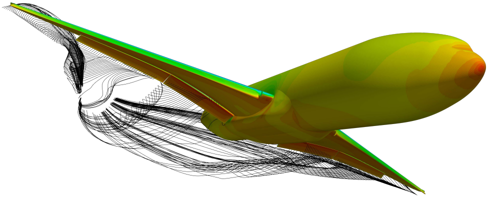
Overview

- Unstructured CFD analysis
  - SU2
  - FUN3D

- CFD analysis setup
  - CFD execution

SU2 Overview

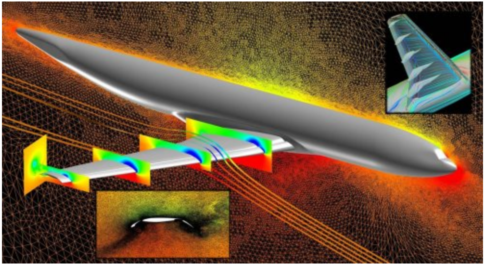
- Open-source CFD solver (https://su2code.github.io/)
- Unstructured meshes
- Mesh deformation
- Adjoint based optimization
- CAPS: 4.1.1. (Cardinal), 5.0.0 (Raven), 6.2.0 (Falcon)
  - 7.0 (Blackbird) in next ESP version



SU2
The Open-Source CFD Code

Fun3D Overview

- Developed at NASA Langley since late 1980s
- Unstructured meshes
- Mesh deformation
- Adjoint based optimization
- Much more
- CAPS: Fun3D 13.4



FUN3D
Fully Unstructured Navier-Stokes

CFD Simulation Outline

- Load geometry
- Generate mesh (the most difficult CFD input to generate)
- Load CFD AIM
  - Set CFD analysis inputs
- Execute CFD
- Extract analysis outputs

session08/su2_1_InviscidWing.py
session08/fun3d_2_InviscidWing.py

session08/su2_1_InviscidWing.py

```
# Load SU2 AIM - child of AFLR3 AIM
su2 = myProblem.loadAIM(aim         = "su2AIM",
                        altName     = "su2",
                        analysisDir = "workDir_SU2_1_InviscidWing",
                        parents     = aflr3.aimName)

# Set project name. Files written to analysisDir will have this name
projectName = "inviscidWing"
su2.setAnalysisVal("Proj_Name", projectName)

su2.setAnalysisVal("Alpha", 1.0)                     # AoA
su2.setAnalysisVal("Mach", 0.5)                      # Mach number
su2.setAnalysisVal("Equation_Type","Compressible") # Equation type
su2.setAnalysisVal("Num_Iter",5)                     # Number of iterations

# Set boundary conditions via capsGroup
inviscidBC = {"bcType" : "Inviscid"}
su2.setAnalysisVal("Boundary_Condition", [("Wing", inviscidBC),
                                          ("Farfield","farfield")])

# Specifcy the boundares used to compute forces
su2.setAnalysisVal("Surface_Monitor", ["Wing"])

# Set SU2 Version
su2.setAnalysisVal("SU2_Version","Falcon")
```

SU2 Execution

- Execute using SU2 python interface

session08/su2_1_InviscidWing.py

```python
# Import SU2 python environment
from parallel_computation import parallel_computation as su2Run
```

```python
# Run AIM pre-analysis
su2.preAnalysis()

####### Run SU2 #######################
print ("\n\nRunning SU2......")
currentDirectory = os.getcwd() # Get our current working directory

os.chdir(su2.analysisDir) # Move into test directory

# Run SU2 with specified number of partitions
su2Run(projectName + ".cfg", partitions = 1)

os.chdir(currentDirectory) # Move back to top directory
#######################################

# Run AIM post-analysis
su2.postAnalysis()
```

SU2 Extracting Analysis Output

- Retrieve forces and moments

session08/su2_1_InviscidWing.py

```
print ("\n==> Total Forces and Moments")
# Get Lift and Drag coefficients
print ("--> Cl = ", su2.getAnalysisOutVal("CLtot"), \
       "Cd = ", su2.getAnalysisOutVal("CDtot"))

# Get Cmx, Cmy, and Cmz coefficients
print ("--> Cmx = ", su2.getAnalysisOutVal("CMXtot"), \
       "Cmy = ", su2.getAnalysisOutVal("CMYtot"), \
       "Cmz = ", su2.getAnalysisOutVal("CMZtot"))

# Get Cx, Cy, Cz coefficients
print ("--> Cx = ", su2.getAnalysisOutVal("CXtot"), \
       "Cy = ", su2.getAnalysisOutVal("CYtot"), \
       "Cz = ", su2.getAnalysisOutVal("CZtot"))
```

session08/fun3d_2_InviscidWing.py

```
# Load FUN3D AIM - child of AFLR3 AIM
fun3d = myProblem.loadAIM(aim         = "fun3dAIM",
                          altName     = "fun3d",
                          analysisDir = "workDir_FUN3D_2_InviscidWing",
                          parents     = aflr3.aimName)

# Set project name. Files written to analysisDir will have this name
projectName = "inviscidWing"
fun3d.setAnalysisVal("Proj_Name", projectName)

fun3d.setAnalysisVal("Alpha", 1.0)                     # AoA
fun3d.setAnalysisVal("Mach", 0.5)                      # Mach number
fun3d.setAnalysisVal("Equation_Type","Compressible") # Equation type
fun3d.setAnalysisVal("Num_Iter",5)                     # Number of iterations

# Set boundary conditions via capsGroup
inviscidBC = {"bcType" : "Inviscid"}
fun3d.setAnalysisVal("Boundary_Condition", [("Wing", inviscidBC),
                                            ("Farfield","farfield")])
```

Fun3D NML Analysis Inputs

- fun3d.nml is very large (and changes with Fun3D versions)
- Not all inputs implemented in AIM
- f90nml used to write directly to fun3d.nml
  - NOTE: Circumvents CLEAN/DIRTY process
  - Always use AIM inputs when available

session08/fun3d_2_InviscidWing.py

```
# Use python to add inputs to fun3d.nml file
fun3d.setAnalysisVal("Use_Python_NML", True)

# Write boundary output variables to the fun3d.nml file directly
fun3dnml = f90nml.Namelist()
fun3dnml['boundary_output_variables'] = f90nml.Namelist()
fun3dnml['boundary_output_variables']['mach'] = True
fun3dnml['boundary_output_variables']['cp'] = True
fun3dnml['boundary_output_variables']['average_velocity'] = True

fun3dnml.write(os.path.join(fun3d.analysisDir,"fun3d.nml"), force=True)
```

Fun3D Execution

- Execute Fun3D using system call

session08/fun3d_2_InviscidWing.py

```
# Run AIM pre-analysis
fun3d.preAnalysis()

####### Run FUN3D #####################
print ("\n==> Running FUN3D......")
currentDirectory = os.getcwd() # Get our current working directory

os.chdir(fun3d.analysisDir) # Move into test directory

# Run fun3d via system call
os.system("nodet_mpi --animation_freq -1 --write_aero_loads_to_file > Info.out")

os.chdir(currentDirectory) # Move back to top directory
#######################################

# Run AIM post-analysis
fun3d.postAnalysis()
```

Fun3D Extracting Analysis Output

- Retrieve forces and moments

session08/fun3d_2_InviscidWing.py

```
# Get force results
print ("\n==> Total Forces and Moments")
# Get Lift and Drag coefficients
print ("--> Cl = ", fun3d.getAnalysisOutVal("CLtot"), \
           "Cd = ", fun3d.getAnalysisOutVal("CDtot"))

# Get Cmx, Cmy, and Cmz coefficients
print ("--> Cmx = ", fun3d.getAnalysisOutVal("CMXtot"), \
           "Cmy = ", fun3d.getAnalysisOutVal("CMYtot"), \
           "Cmz = ", fun3d.getAnalysisOutVal("CMZtot"))

# Get Cx, Cy, Cz coefficients
print ("--> Cx = ", fun3d.getAnalysisOutVal("CXtot"), \
           "Cy = ", fun3d.getAnalysisOutVal("CYtot"), \
           "Cz = ", fun3d.getAnalysisOutVal("CZtot"))
```

Future CFD Simulation Outline

Current Process

- Load geometry
- Generate mesh
- Load CFD AIM
- Execute CFD
- Extract analysis outputs

Future Process

- Load geometry
- Load CFD AIM
- for_each DESPMTR
    - Generate mesh
    - for_each Anlysis_Input
        - Generate CFD input files
- Execute all CFD jobs
- Extract analysis outputs for all jobs