Problem Workshop II: Design and Optimization Using SU^2

SU^2 Release Version 2.0 Workshop

Stanford University

Tuesday, January 15th, 2013

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ONERA M6 Shape Optimization

1. Run direct, and rename the files (check non-dimensional parameters).
2. Run adjoint problems, and rename the files.
3. Visualize and check direct and adjoint solutions.
4. Identify corners of the FFD box and define the degree of the FFD box.
5. Run SU2_MDC to create the .su2 with FFD information (rename output .su2 file).
6. Define design variables and compute gradient.
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8. Run the optimization.

```
fpalacios@oscarthegrouch:~/SU2/trunk/TestCases/cont_adj_euler/oneram6 — ...
% ------------- DIRECT, ADJOINT, AND LINEARIZED PROBLEM DEFINITION ------------%
%
% Physical governing equations (POTENTIAL_FLOW, EULER, NAVIER_STOKES,
%                               MULTI_SPECIES_NAVIER_STOKES, TWO_PHASE_FLOW,
%                               COMBUSTION)
PHYSICAL_PROBLEM= EULER
%
% Mathematical problem (DIRECT, ADJOINT, LINEARIZED, ONE_SHOT_ADJOINT)
MATH_PROBLEM= DIRECT
%
% Restart solution (NO, YES)
RESTART_SOL= NO

% ----------- COMPRESSIBLE AND INCOMPRESSIBLE FREE-STREAM DEFINITION ----------%
%
% Mach number (non-dimensional, based on the free-stream values)
MACH_NUMBER= 0.8395
%
% Angle of attack (degrees)
AoA= 3.06
%
% Side-slip angle (degrees)
SIDESLIP_ANGLE= 0.0
%
% Free-stream pressure (101325.0 N/m^2 by default, only for Euler equations)
FREESTREAM_PRESSURE= 101325.0
%
% Free-stream temperature (273.15K by default)
FREESTREAM_TEMPERATURE= 273.15

% -------------- COMPRESSIBLE AND INCOMPRESSIBLE FLUID CONSTANTS --------------%
%
% Ratio of specific heats (1.4 (air), only for compressible flows)
GAMMA_VALUE= 1.4
%
% Specific gas constant (287.87 J/kg*K (air), only for compressible flows)
GAS_CONSTANT= 287.87

-- INSERT --                                                     12,1          3%

[fpalacios@oscarthegrouch oneram6]$ parallel_computation.py -f inv_ONERAM6.cfg -p 12

 Iter    Time(s)     Res[Rho]     Res[RhoE]   CLift(Total)   CDrag(Total)
  100   0.482772   -5.412326    -4.782066      0.285536       0.012296
  101   0.482745   -5.440343    -4.817595      0.285536       0.012296
  102   0.482816   -5.470371    -4.858746      0.285536       0.012296

[fpalacios@oscarthegrouch oneram6]$ mv restart_flow.dat solution_flow.dat
```

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fpalacios@oscarthegrouch:~/SU2/trunk/TestCases/cont_adj_euler/oneram6 ...

```
PHYSICAL_PROBLEM= EULER
%
% Mathematical problem (DIRECT, ADJOINT, LINEARIZED, ONE_SHOT_ADJOINT)
MATH_PROBLEM= ADJOINT
%
% Restart solution (NO, YES)
RESTART_SOL= NO

-- INSERT --                                                17,1          4%
```

fpalacios@oscarthegrouch:~/SU2/trunk/TestCases/cont_adj_euler/oneram6 — ...

```
% --------------------- FLOW NUMERICAL METHOD DEFINITION ----------------------%
% Convective numerical method: (JST, LAX-FRIEDRICH, ROE-1ST_ORDER,
%                               ROE-2ND_ORDER)
CONV_NUM_METHOD_FLOW= JST
%
% Slope limiter: (NONE, VENKATAKRISHNAN)
SLOPE_LIMITER_FLOW= NONE
%
% 1st, 2nd and 4th order artificial dissipation coefficients
AD_COEFF_FLOW= ( 0.15, 0.5, 0.04 )
%
% Time discretization (RUNGE-KUTTA_EXPLICIT, EULER_IMPLICIT, EULER_EXPLICIT)
TIME_DISCRE_FLOW= EULER_IMPLICIT

% ----------------- ADJOINT-FLOW NUMERICAL METHOD DEFINITION ------------------%
% Adjoint problem boundary condition (DRAG, LIFT, SIDEFORCE, PRESSURE, MOMENT_X,
%                                     MOMENT_Y, MOMENT_Z, EFFICIENCY,
%                                     EQUIVALENT_AREA, NEARFIELD_PRESSURE)
ADJ_OBJFUNC= DRAG
%
% Convective numerical method: (JST, LAX-FRIEDRICH, ROE-1ST_ORDER,
%                               ROE-2ND_ORDER)
CONV_NUM_METHOD_ADJ= JST
%
% 1st, 2nd, and 4th order artificial dissipation coefficients
AD_COEFF_ADJ= ( 0.15, 0.0, 0.04 )
%
% Reduction factor of the CFL coefficient in the adjoint problem
ADJ_CFL_REDUCTION= 0.75
%
% Time discretization (RUNGE-KUTTA_EXPLICIT, EULER_IMPLICIT)
TIME_DISCRE_ADJ= EULER_IMPLICIT
                                                            140,1         46%
```

```
[fpalacios@oscarthegrouch oneram6]$ parallel_computation.py -f inv_ONERAM6.cfg -p 12
[fpalacios@oscarthegrouch oneram6]$ mv restart_adj_cd.dat solution_adj_cd.dat
[fpalacios@oscarthegrouch oneram6]$ mv restart_adj_cl.dat solution_adj_cl.dat
```

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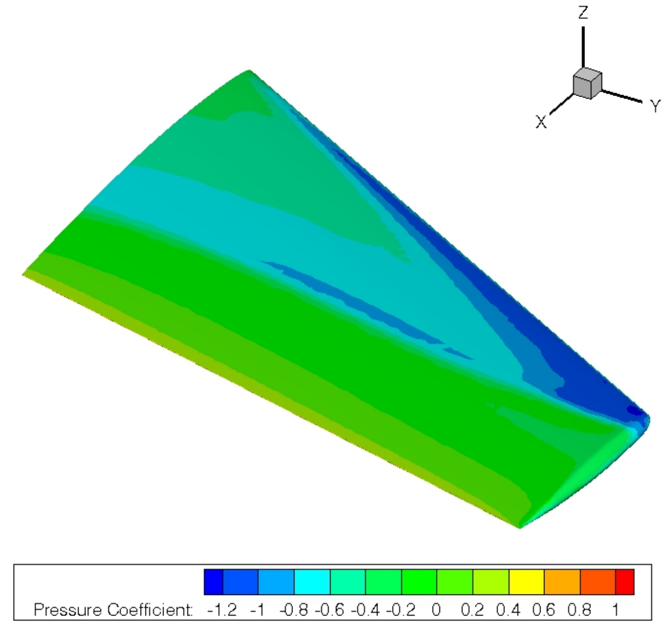

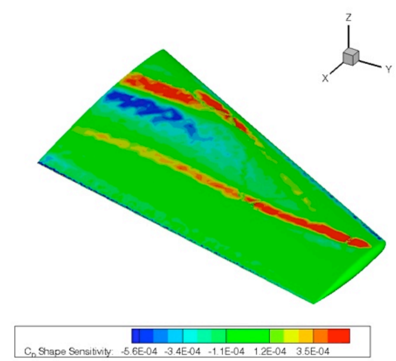

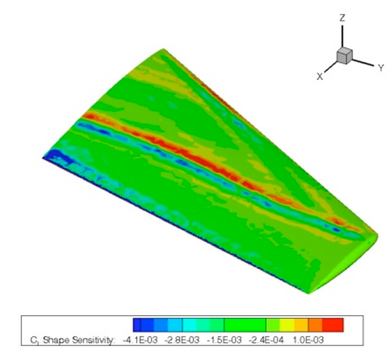

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fpalacios@oscarthegrouch:~/SU2/trunk/TestCases/cont_adj_euler/oneram6 ...

```
% ----------------------- GRID DEFORMATION PARAMETERS -----------------------%
%
% Kind of deformation (NO_DEFORMATION, HICKS_HENNE, PARABOLIC, NACA_4DIGITS,
%                      DISPLACEMENT, ROTATION, FFD_CONTROL_POINT,
%                      FFD_DIHEDRAL_ANGLE, FFD_TWIST_ANGLE,
%                      FFD_ROTATION, FFD_CAMBER, FFD_THICKNESS, FFD_VOLUME)
DV_KIND= NO_DEFORMATION
%
% Marker of the surface in which we are going apply the shape deformation
DV_MARKER= ( UPPER_SIDE, LOWER_SIDE, TIP )
%
% Parameters of the shape deformation
%       - FFD_CONTROL_POINT ( Chunk, i_Ind, j_Ind, k_Ind, x_Disp, y_Disp, z_Disp
 )
%       - FFD_DIHEDRAL_ANGLE ( Chunk, x_Orig, y_Orig, z_Orig, x_End, y_End, z_En
d )
%       - FFD_TWIST_ANGLE ( Chunk, x_Orig, y_Orig, z_Orig, x_End, y_End, z_End )
%       - FFD_ROTATION ( Chunk, x_Orig, y_Orig, z_Orig, x_End, y_End, z_End )
%       - FFD_CAMBER ( Chunk, i_Ind, j_Ind )
%       - FFD_THICKNESS ( Chunk, i_Ind, j_Ind )
%       - FFD_VOLUME ( Chunk, i_Ind, j_Ind )
DV_PARAM= ( 0, 2.5, 0.0, 0.0, 2.5, 20.0, 0.0 )
%
% Old value of the deformation for incremental deformations
DV_VALUE_OLD= 0.0
%
% New value of the shape deformation
DV_VALUE_NEW= 5.0
%
% Grid deformation technique (SPRING, TORSI
GRID_DEFORM_METHOD= SPRING
%
% Maximum error in the grid deformation
GRID_DEFORM_ERROR= 1E-4
%
% Visualize the deformation (NO, YES)
VISUALIZE_DEFORMATION= NO
```

Terminal — vim — 36×24

```
5       9202    9205    9201
5       483     1677    8773
5       4678    19336   19323
NCHUNK= 1
NLEVEL= 1
CHUNK_TAG= 0
CHUNK_LEVEL= 0
CHUNK_DEGREE_I= 5
CHUNK_DEGREE_J= 4
CHUNK_DEGREE_K= 1
CHUNK_PARENTS= 0
CHUNK_CHILDREN= 0
CHUNK_CORNER_POINTS=8
-0.5 0 -0.6
8.5 0 -0.6
13 16 -0.6
8.5 16 -0.6
-0.5 0 0.6
8.5 0 0.6
13 16 0.6
8.5 16 0.6
CHUNK_CONTROL_POINTS=0
CHUNK_SURFACE_POINTS=0
```

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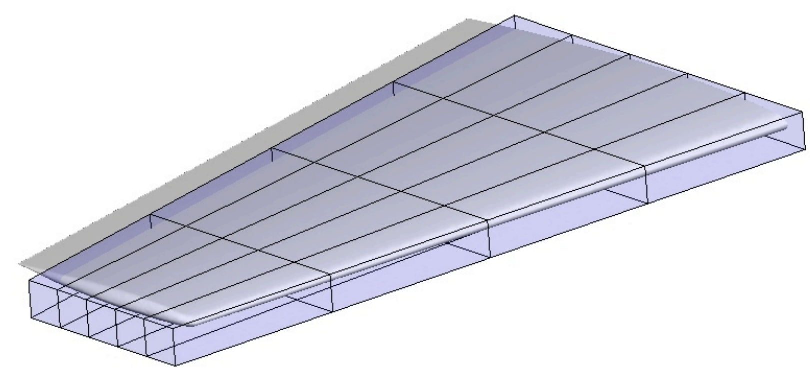
```
[fpalacios@oscarthegrouch oneram6]$ SU2_MDC inv_ONERAM6.cfg
```

Terminal — bash — 74×21

```
------------------------- Surface grid deformation ----------------------
No deformation of the surface grid.
1 Free Form Deformation (FFD) chunks.
1 Free Form Deformation (FFD) nested levels.
FFD box tag: 0. FFD box level: 0. Degrees: 5, 4, 1.
Number of parent boxes: 0. Number of child boxes: 0.
Corner points: 8. Control points: 0. Surface points: 0.

----------------- FFD technique (cartesian -> parametric) ---------------
Compute parametric coord      | FFD box: 0. Max diff: 2.02537e-14.

----------------- FFD technique (parametric -> cartesian) ---------------
Update cartesian coord        | FFD box: 0. Max diff: 2.02537e-14.

----------------------- Volumetric grid deformation ---------------------
No deformation deformation of the volumetric grid.
End and write output files.

------------------------- Exit Success (SU2_MDC) ------------------------

Francisco-Palacioss-MacBook-Pro:ONERAM6_Tutorial fpalacios$
```



```
fpalacios$ mv mesh_out.su2 mesh_ONERAM6_inv_FFD.su2
```

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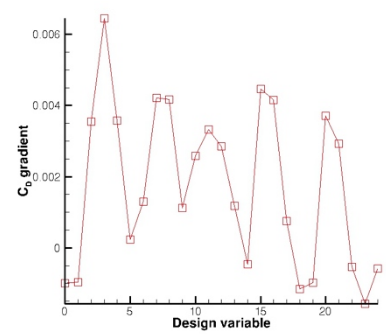
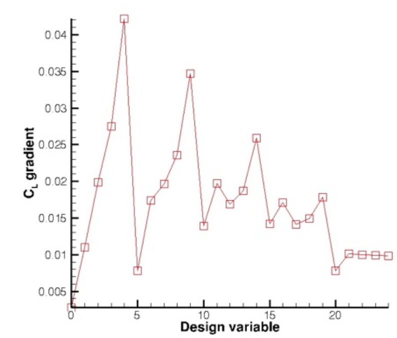
```
% List of design variables (Design variables are separated by semicolons)
%  - FFD_CONTROL_POINT ( 7, Scale | Mark. List | Chunk, i_Ind, j_Ind, k_Ind, x_Mov, y_Mov, z_Mov )
DEFINITION_DV= ( 7, 1.0 | UPPER_SIDE, LOWER_SIDE, TIP | 0, 0, 0, 1, 0.0, 0.0, 1.0 ); ( 7, 1.0 | UPP
ER_SIDE, LOWER_SIDE, TIP | 0, 1, 0, 1, 0.0, 0.0, 1.0 ); ( 7, 1.0 | UPPER_SIDE, LOWER_SIDE, TIP | 0,
 2, 0, 1, 0.0, 0.0, 1.0 ); ( 7, 1.0 | UPPER_SIDE, LOWER_SIDE, TIP | 0, 3, 0, 1, 0.0, 0.0, 1.0 ); (
7, 1.0 | UPPER_SIDE, LOWER_SIDE, TIP | 0, 4, 0, 1, 0.0, 0.0, 1.0 ); ( 7, 1.0 | UPPER_SIDE, LOWER_SI
DE, TIP | 0, 0, 1, 1, 0.0, 0.0, 1.0 ); ( 7, 1.0 | UPPER_SIDE, LOWER_SIDE, TIP | 0, 1, 1, 1, 0.0, 0.
0, 1.0 ); ( 7, 1.0 | UPPER_SIDE, LOWER_SIDE, TIP | 0, 2, 1, 1, 0.0, 0.0, 1.0 ); ( 7, 1.0 | UPPER_SI
DE, LOWER_SIDE, TIP | 0, 3, 1, 1, 0.0, 0.0, 1.0 ); ( 7, 1.0 | UPPER_SIDE, LOWER_SIDE, TIP | 0, 4, 1
, 1, 0.0, 0.0, 1.0 ); ( 7, 1.0 | UPPER_SIDE, LOWER_SIDE, TIP | 0, 0, 2, 1, 0.0, 0.0, 1.0 ); ( 7, 1.
0 | UPPER_SIDE, LOWER_SIDE, TIP | 0, 1, 2, 1, 0.0, 0.0, 1.0 ); ( 7, 1.0 | UPPER_SIDE, LOWER_SIDE, T
IP | 0, 2, 2, 1, 0.0, 0.0, 1.0 ); ( 7, 1.0 | UPPER_SIDE, LOWER_SIDE, TIP | 0, 3, 2, 1, 0.0, 0.0, 1.
0 ); ( 7, 1.0 | UPPER_SIDE, LOWER_SIDE, TIP | 0, 4, 2, 1, 0.0, 0.0, 1.0 ); ( 7, 1.0 | UPPER_SIDE, L
OWER_SIDE, TIP | 0, 0, 3, 1, 0.0, 0.0, 1.0 ); ( 7, 1.0 | UPPER_SIDE, LOWER_SIDE, TIP | 0, 1, 3, 1,
0.0, 0.0, 1.0 ); ( 7, 1.0 | UPPER_SIDE, LOWER_SIDE, TIP | 0, 2, 3, 1, 0.0, 0.0, 1.0 ); ( 7, 1.0 | U
PPER_SIDE, LOWER_SIDE, TIP | 0, 3, 3, 1, 0.0, 0.0, 1.0 ); ( 7, 1.0 | UPPER_SIDE, LOWER_SIDE, TIP |
0, 4, 3, 1, 0.0, 0.0, 1.0 ); ( 7, 1.0 | UPPER_SIDE, LOWER_SIDE, TIP | 0, 0, 4, 1, 0.0, 0.0, 1.0 );
( 7, 1.0 | UPPER_SIDE, LOWER_SIDE, TIP | 0, 1, 4, 1, 0.0, 0.0, 1.0 ); ( 7, 1.0 | UPPER_SIDE, LOWER_
SIDE, TIP | 0, 2, 4, 1, 0.0, 0.0, 1.0 ); ( 7, 1.0 | UPPER_SIDE, LOWER_SIDE, TIP | 0, 3, 4, 1, 0.0,
0.0, 1.0 ); ( 7, 1.0 | UPPER_SIDE, LOWER_SIDE, TIP | 0, 4, 4, 1, 0.0, 0.0, 1.0 )
```

```
$ continuous_adjoint.py -f inv_ONERAM6.cfg -p 12 -c False
```





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fpalacios@oscarthegrouch:~/SU2/trunk/TestCases/cont_adj_euler/oneram6 — ...

```
% -------------------- OPTIMAL SHAPE DESIGN DEFINITION ----------------------%
%
% Objective function (DRAG, LIFT, SIDEFORCE, PRESSURE, MOMENT_X, MOMENT_Y,
%                     MOMENT_Z, EFFICIENCY, EQUIVALENT_AREA, NEARFIELD_PRESSURE,
%                     FORCE_X, FORCE_Y, FORCE_Z, THRUST, TORQUE, FIGURE_OF_MERIT
%                     FREESURFACE)
OBJFUNC= DRAG
%
% Scale objective funtion.
OBJFUNC_SCALE= 100.0
%
% Inequality constraints list separated by comma (DRAG, LIFT, SIDEFORCE, PRESSURE,
 MOMENT_X, MOMENT_Y,
%                     MOMENT_Z, EFFICIENCY, EQUIVALENT_AREA, NEARFIELD_PRESSURE,
%                     FORCE_X, FORCE_Y, FORCE_Z, THRUST, TORQUE, FIGURE_OF_MERIT
%                     FREESURFACE)
CONST_IEQ= LIFT
%
% Scale inequality constraints (separated by comma)
CONST_IEQ_SCALE= 100.0
%
% Min value inequality constraints list (NONE, LESS, GREATER)
CONST_IEQ_SIGN= GREATER
%
% Max value inequality constraints list (separated by comma)
CONST_IEQ_VALUE= 0.2855362768
%
% Equality constraints list separated by comma (DRAG, LIFT, SIDEFORCE, PRESSURE, M
OMENT_X, MOMENT_Y,
%                     MOMENT_Z, EFFICIENCY, EQUIVALENT_AREA, NEARFIELD_PRESSURE,
%                     FORCE_X, FORCE_Y, FORCE_Z, THRUST, TORQUE, FIGURE_OF_MERIT
%                     FREESURFACE)
CONST_EQ= NONE
%
% Scale equality constraints (separated by comma)
CONST_EQ_SCALE= 0.0
%
% Value equality constraints list (separated by comma)
CONST_EQ_VALUE= 0.0
%
% List of design variables (Design variables are separated by semicolons)
%  - FFD_CONTROL_POINT ( 7, Scale | Mark. List | Chunk, i_Ind, j_Ind, k_Ind, x_Mov
, y_Mov, z_Mov )
                                                                332,1         99%
```

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```
$ shape_optimization.py -f inv_ONERAM6.cfg -p 12
```