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Import data from text file.

Script for importing data from the following text file:

```
%C:\Users\Prateek\Documents\MATLAB\Airfoil_opt\airfoil optim
\xfoil_a00.500_cpwr.dat
%
% To extend the code to different selected data or a different text
 file,
% generate a function instead of a script.
```

Initialize variables.

```
%%PLEASE CHANGE THE DIRECTORY OF THE FILE, DEPENDING ON WHERE YOU'RE
%%RUNNING THIS MATLAB CODE. ENTER THE DIRCTORY FOR,
 'xfoil_a00.500_cpwr.dat'.

filename = '\\ad.uillinois.edu\engr\instructional\paintal2\documents
\MATLAB\413_Project\xfoil_a00.500_cpwr.dat';
startRow = 4;
```

Format string for each line of text:

```
column1: double (%f)

% column2: double (%f)
%   column3: double (%f)
% For more information, see the TEXTSCAN documentation.
formatSpec = '%10f%9f%f%[^\n\r]';
```

Open the text file.

```
fileID = fopen(filename,'r');
```

Read columns of data according to format string.

This call is based on the structure of the file used to generate this code. If an error occurs for a different file, try regenerating the code from the Import Tool.

```
dataArray = textscan(fileID,
 formatSpec, 'Delimiter', '', 'WhiteSpace', '', 'HeaderLines'
 ,startRow-1, 'ReturnOnError', false);
```

Close the text file.

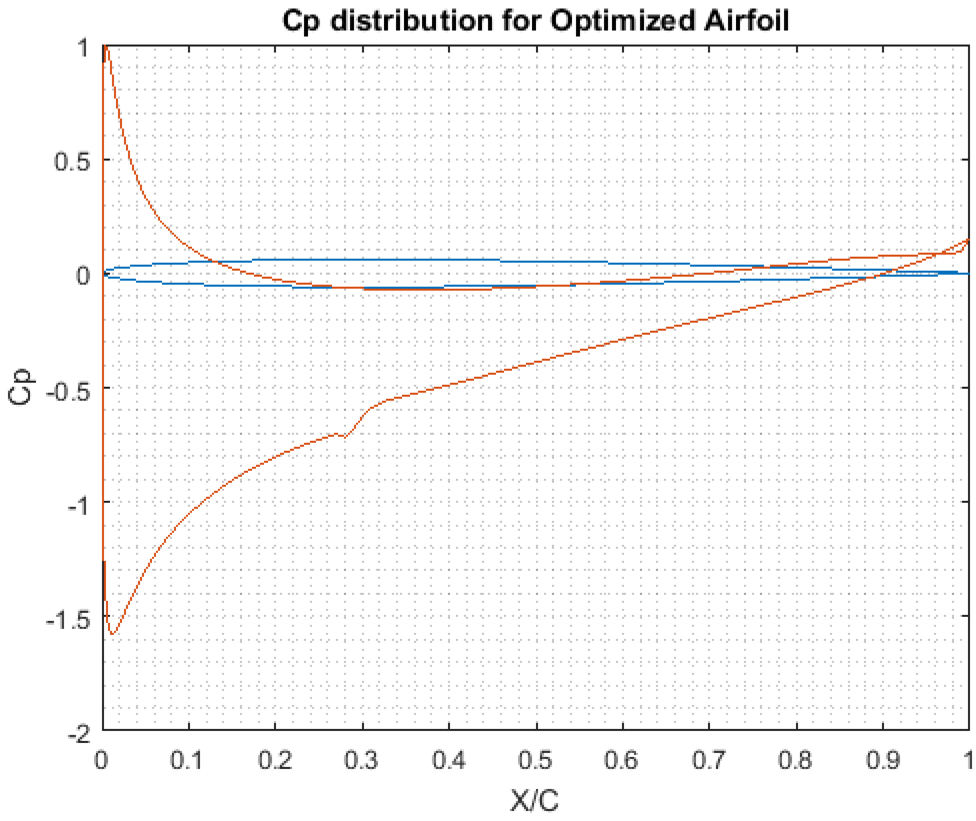
```
fclose(fileID);
```

Post processing for unimportable data.

No unimportable data rules were applied during the import, so no post processing code is included. To generate code which works for unimportable data, select unimportable cells in a file and regenerate the script.

Allocate imported array to column variable names

```
X = dataArray{:, 1};
Y = dataArray{:, 2};
Cp = dataArray{:, 3};
Cp = Cp;
figure
plot(X,Y)
hold on
plot(X,Cp)
grid minor
xlabel('X/C')
ylabel('Cp')
title('Cp distribution for Optimized Airfoil')
%axis equal
```



Clear temporary variables

```
clearvars filename startRow formatSpec fileID dataArray ans;
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%% Optimizing Wing Parameters %%%%%%%
%%%%%%%%%%%%%%%%%%%%%%
clc;
options = optimset('MaxFunEvals', 10000,'LargeScale', 'on');
A = []; B = []; Aeq = []; beq = [];
lb = [0,0,0.2,10,15,0]; ub = [10 10 0.85 35 200 5];
x0 = [2.8,1.45,0.9,14,30,1];

% Establishing Constants and wing parameters:
global Cl, global pi, global e, global Mr, global Lb, global rh
global Nlift, global sigmaMax, global sigmaMaxSh, global t, global g
global tcap, global tweb, global tau, global Icap, global wbar, global
 rhoCap, global rhoWeb

%Defining Constants and Parameters:
Mr = 64156.67;  %Upper Limit Moment at the root chord of the wing.
Lb = 5200;  %Weight of the Aircaft excluding wing.
Nlift = 6.0;  %Wing loading Multiplier.
sigmaMax = 25e7;  % Maximum allowable Stress
sigmaMaxSh = 167e6;  % MAximum allowable Shear Stress
Cl=0.65; % Desired Lift Coefficient
pi = 3.14159265;  % Value of 'pi'
```

```
e = 0.95; % Wing psan efficiency
t = 0.25; % 't' ranges from 0.117 to 0.312m Maintaining constant
 thickness of the airfoil
tcap = 0.00427310;  % Thickness of the spar cap per unit chord
tweb = 0.000591;  %shear web thickness per unti chord
wbar =0.5;   %The ratio of wing box length/Chord_Length
rhoCap =2700;  %Density of the Cap
g = 9.81; % Gravitaionl Constant
rhoWeb = 2700; %Density of the web
rh= 0.75; % Wing parameter constant
Icap = 1.908e-5; %Moment of Inertia Per unit span.
tau = 0.15; %Ratio of max thickness of wing section to local chord.

%The decision variables are as follows:
%Y[]=[p, q, lambda, b, S, A, v(lambda)]

%Compute the objective function and optimum values for the wing:
warning off
% [xopt, fval] = fmincon('Drag_obj_fn', x0, A, B, Aeq, beq, lb, ub,...
%'Wingdrag_Con',options);

%MultiStart/Global Search
options = optimoptions(@fmincon,'Algorithm','sqp');
problem = createOptimProblem('fmincon','objective',...
@(x)(Cl^2*(pi*e*x(4)^2/x(5))^-1),'x0',[2.8,1.45,0.9,14,30,1],...
'lb',[0,0,0.2,10,15,0], 'ub',[10 10 0.85 32 60
 5],'nonlcon',@Wingdrag_Con,'options',options);
ms = MultiStart;
gs = GlobalSearch;
warning off
%[xopt,fval] = run(gs,problem);
global xopt;
warning off
[xopt,fval] = run(ms,problem,100);

format long
display('The output values are given below: ');
display(['Minimum Cdi value is found to be = ', num2str(fval)]);
display('Y[]=[p,  q,  lambda,  b,  S,  v(lambda):');
xopt(10)= xopt(4)^2/xopt(5);
display(['[',num2str(xopt(1:6)),']']);
xopt(7) =0.115; % Data obtained from wing section (airfoil)
 optimization.
xopt(8) =-0.98; % Data obtained from wing section (airfoil)
 optimization.
xopt(9) =3.417; % Data obtained from wing section (airfoil)
 optimization.


MultiStart completed some of the runs from the start points.

4 out of 100 local solver runs converged with a positive local solver
 exit flag.
The output values are given below:
```

```
Minimum Cdi value is found to be = 0.0075286
Y[]=[p,  q,  lambda,  b,  S,  v(lambda):
[2.7        1.85        0.85      17.0523      15.4641     0.751848]
```

Lifting Line Theory - Validation of the results

This is a simple function for solving lifting-line theory / monoplane equation It assumes that the wing is not maneuvering, i.e., there are no aileron deflections, and so only odd terms on the sine series are used to create a symmetric lift distribution. Inputs: a0 = Sectional lift curve slope per radians (normally 2*pi) AR = Aspect ratio of wing lambda = Taper ratio, c_t/c_r alpha0l = Sectional zero lift angle of attack in degrees alpha = Geometric angle of attack in degrees numlocs = Number of spanwise stations / terms in sine series Outputs: CL = Wing lift coefficient CDi = Induced drag coefficient e = Span efficiency factor Created by: Joseph Derlaga Modified by: Angad Paintal

```
a0 = 2.1*pi;
AR = xopt(4)^2/xopt(5);
lambda = xopt(3);
alpha0l = xopt(8);
alpha = xopt(9);
numlocs = 57;
%a0 = 0.115; AR = xopt(6); lambda =xopt(3); alpha01=-3.5; alpha=5;
 numlocs=57;
```

Convert degree values to radians

```
        Depending on your version of Matlab, you can use either of these methods
```

```
alphar = alpha*pi/180;
alpha0lr = alpha0l*pi/180;

%alphar = degtorad(alpha);
%alpha0lr = degtorad(alpha0l);
```

Initialize work arrays

```
LHS = zeros(numlocs,numlocs);
RHS = zeros(numlocs,1);
phi = zeros(numlocs,1);
Cl  = zeros(numlocs,1);
```

Angles for station locations

```
for n = 1:numlocs
    phi(n) = n*pi/(2*numlocs);
end
% Could vectorize the above lines
```

Create the system of equations for solving LLT/Monoplane Equation

```
for a = 1:numlocs
```

```
    mu = (a0 / ( 2 * AR * ( 1 + lambda ) )) * (1 + (lambda -
 1 )*cos(phi(a)));
    RHS(a,1) = mu * ( alphar - alpha0lr ) * sin(phi(a));

    for n = 1:2:2*numlocs-1
        LHS(a,(n+1)/2) = sin(n*phi(a)) * ( n*mu + sin(phi(a)) );
    end

end
% Could vectorize some of the above lines
```

Solve

```
A = LHS\RHS;
```

Extract quantities of interest

```
CL = A(1)*pi*AR;
for n = 1:numlocs
    Asum = 0;
    for m = 1:numlocs
        Asum = Asum + A(m) * sin( (2*m-1) * phi(n) );
    end
    % Could replace the above for loop with:
    %Asum = sum(A(1:numlocs).*sin(2*(1:numlocs)-1)'*phi(n));
    Cl(n) = 2 * AR *( 1 + lambda ) * ...
        (1 / ( 1 + ( lambda - 1 ) * cos(phi(n)) )) * Asum;
end

einv = 0;
for n = 1:numlocs
    einv = einv + (2*n-1)*A(n)^2/A(1)^2;
end
% Could replace the above for loop with:
%einv = sum( (2*(1:numlocs)-1)*A(1:numlocs).^2/A(1)^2 );

CDi = 2.5*einv*CL^2/(pi*AR);

e = 1/einv;
%display(['Lif is found to be = ', num2str(Cl)]);
display(['Cdi for 3-D wing, using LLT = ', num2str(CDi)]);
```

```
Cdi for 3-D wing, using LLT = 0.0092952
```

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