Initialize Parameters

```
clear;
evaluationFunction = 'evaluateNacaShape';
p(1).nacaNumber = [0,0,1,2];
name{1} = 'NACA 0012';
p(2).nacaNumber = [5,5,2,2];
name{2} = 'NACA 5522';
p(3).nacaNumber = [9,7,3,5];
name{3} = '9735';
```

Run Experiments

```
for experiment = 1:3
   clear bestFitness medianFitness bestSolution;
   parfor run = 1:100
      fprintf('Performing exp %d, run %d\n',experiment, run);
      r(run) = cmaes(evaluationFunction, 32, p(experiment));
      bestFitness(run,:) = r(run).bestFitness;
      meanFitness(run,:) = r(run).meanFitness;
      bestSolution(:,run) = r(run).bestSolution;

   end
   p(experiment).meanBestFitness = mean(bestFitness,1);
   p(experiment).meanMeanFitness = mean(meanFitness,1);
   [fitness, index] = sort(bestFitness(:,end),1);
   p(experiment).bestSolution = bestSolution(:,index(1));
end
```

```
Performing exp 1, run 17
Performing exp 1, run 16
Performing exp 1, run 34
Performing exp 1, run 33
Performing exp 1, run 51
Performing exp 1, run 50
Performing exp 1, run 64
Performing exp 1, run 63
Performing exp 1, run 15
Performing exp 1, run 32
Performing exp 1, run 62
Performing exp 1, run 49
Performing exp 1, run 14
Performing exp 1, run 31
Performing exp 1, run 61
Performing exp 1, run 48
Performing exp 1, run 13
Performing exp 1, run 30
Performing exp 1, run 47
Performing exp 1, run 60
Performing exp 1, run 12
Performing exp 1, run 29
Performing exp 1, run 46
Performing exp 1, run 59
Performing exp 1, run 11
Performing exp 1, run 28
Performing exp 1, run 45
Performing exp 1, run 58
Performing exp 1, run 10
Performing exp 1, run 27
```

```
Performing exp 1, run 44
Performing exp 1, run 57
Performing exp 1, run 9
Performing exp 1, run 26
Performing exp 1, run 43
Performing exp 1, run 56
Performing exp 1, run 8
Performing exp 1, run 25
Performing exp 1, run 42
Performing exp 1, run 55
Performing exp 1, run 7
Performing exp 1, run 24
Performing exp 1, run 41
Performing exp 1, run 54
Performing exp 1, run 6
Performing exp 1, run 23
Performing exp 1, run 40
Performing exp 1, run 53
Performing exp 1, run 5
Performing exp 1, run 22
Performing exp 1, run 39
Performing exp 1, run 52
Performing exp 1, run 4
Performing exp 1, run 21
Performing exp 1, run 38
Performing exp 1, run 3
Performing exp 1, run 20
Performing exp 1, run 37
Performing exp 1, run 73
Performing exp 1, run 72
Performing exp 1, run 2
Performing exp 1, run 19
Performing exp 1, run 36
Performing exp 1, run 71
Performing exp 1, run 1
Performing exp 1, run 18
Performing exp 1, run 35
Performing exp 1, run 70
Performing exp 1, run 69
Performing exp 1, run 80
Performing exp 1, run 79
Performing exp 1, run 85
Performing exp 1, run 84
Performing exp 1, run 89
Performing exp 1, run 88
Performing exp 1, run 68
Performing exp 1, run 78
Performing exp 1, run 83
Performing exp 1, run 87
Performing exp 1, run 67
Performing exp 1, run 77
Performing exp 1, run 82
Performing exp 1, run 86
Performing exp 1, run 66
Performing exp 1, run 76
Performing exp 1, run 81
Performing exp 1, run 65
Performing exp 1, run 75
Performing exp 1, run 92
Performing exp 1, run 91
Performing exp 1, run 74
Performing exp 1, run 95
Performing exp 1, run 94
Performing exp 1, run 90
Performing exp 1, run 98
Performing exp 1, run 97
Performing exp 1, run 93
Performing exp 1, run 96
```

```
Performing exp 1, run 100
Performing exp 1, run 99
Performing exp 2, run 17
Performing exp 2, run 16
Performing exp 2, run 64
Performing exp 2, run 63
Performing exp 2, run 34
Performing exp 2, run 33
Performing exp 2, run 51
Performing exp 2, run 50
Performing exp 2, run 15
Performing exp 2, run 32
Performing exp 2, run 49
Performing exp 2, run 62
Performing exp 2, run 14
Performing exp 2, run 31
Performing exp 2, run 48
Performing exp 2, run 61
Performing exp 2, run 13
Performing exp 2, run 47
Performing exp 2, run 30
Performing exp 2, run 60
Performing exp 2, run 12
Performing exp 2, run 46
Performing exp 2, run 29
Performing exp 2, run 59
Performing exp 2, run 11
Performing exp 2, run 45
Performing exp 2, run 28
Performing exp 2, run 58
Performing exp 2, run 10
Performing exp 2, run 44
Performing exp 2, run 27
Performing exp 2, run 57
Performing exp 2, run 9
Performing exp 2, run 43
Performing exp 2, run 26
Performing exp 2, run 56
Performing exp 2, run 8
Performing exp 2, run 42
Performing exp 2, run 25
Performing exp 2, run 55
Performing exp 2, run 7
Performing exp 2, run 41
Performing exp 2, run 24
Performing exp 2, run 54
Performing exp 2, run 6
Performing exp 2, run 23
Performing exp 2, run 40
Performing exp 2, run 53
Performing exp 2, run 5
Performing exp 2, run 22
Performing exp 2, run 39
Performing exp 2, run 52
Performing exp 2, run 4
Performing exp 2, run 21
Performing exp 2, run 38
Performing exp 2, run 3
Performing exp 2, run 20
Performing exp 2, run 37
Performing exp 2, run 73
Performing exp 2, run 72
Performing exp 2, run 2
Performing exp 2, run 19
Performing exp 2, run 36
Performing exp 2, run 71
Performing exp 2, run 1
Performing exp 2, run 18
```
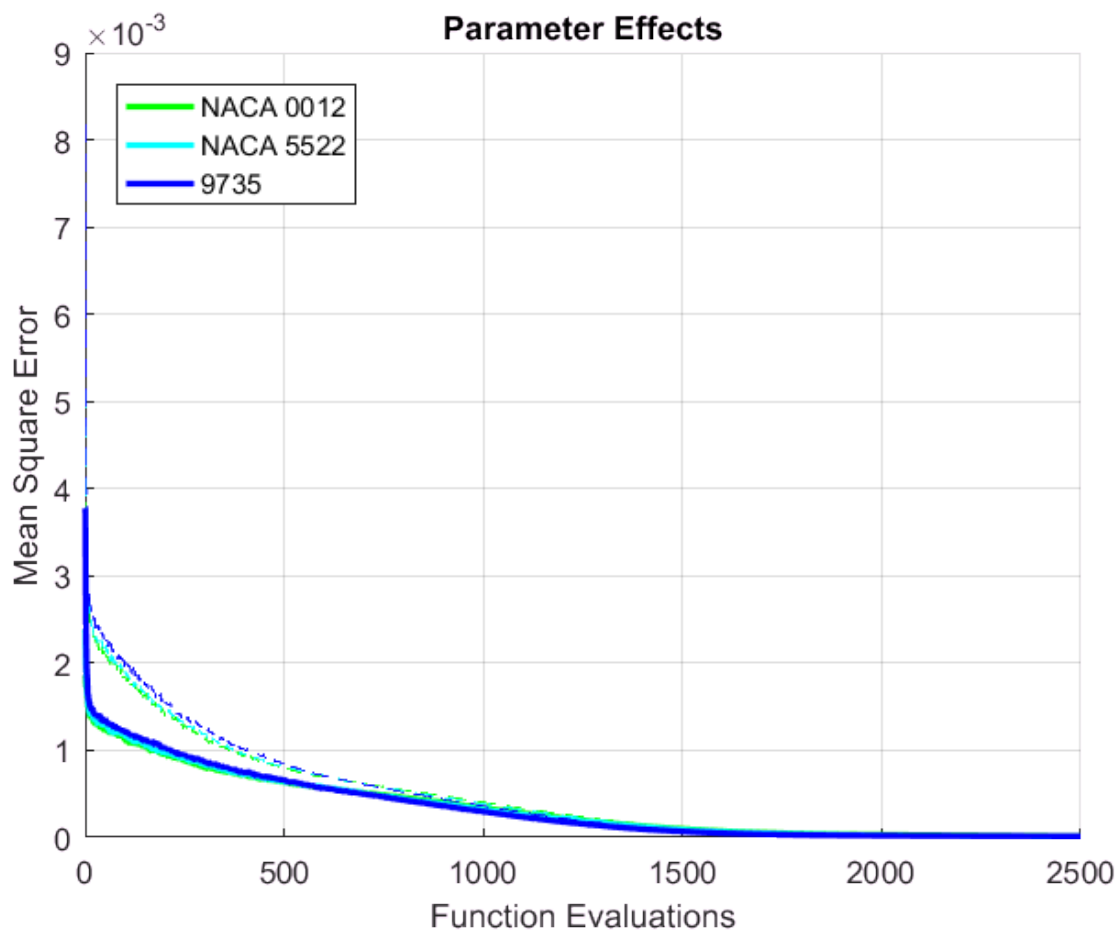
```
Performing exp 2, run 35
Performing exp 2, run 70
Performing exp 2, run 69
Performing exp 2, run 80
Performing exp 2, run 79
Performing exp 2, run 85
Performing exp 2, run 84
Performing exp 2, run 89
Performing exp 2, run 88
Performing exp 2, run 68
Performing exp 2, run 78
Performing exp 2, run 83
Performing exp 2, run 87
Performing exp 2, run 67
Performing exp 2, run 77
Performing exp 2, run 82
Performing exp 2, run 86
Performing exp 2, run 66
Performing exp 2, run 76
Performing exp 2, run 81
Performing exp 2, run 65
Performing exp 2, run 75
Performing exp 2, run 92
Performing exp 2, run 91
Performing exp 2, run 74
Performing exp 2, run 95
Performing exp 2, run 94
Performing exp 2, run 90
Performing exp 2, run 98
Performing exp 2, run 97
Performing exp 2, run 93
Performing exp 2, run 96
Performing exp 2, run 100
Performing exp 2, run 99
Performing exp 3, run 17
Performing exp 3, run 16
Performing exp 3, run 34
Performing exp 3, run 33
Performing exp 3, run 51
Performing exp 3, run 50
Performing exp 3, run 64
Performing exp 3, run 63
Performing exp 3, run 15
Performing exp 3, run 32
Performing exp 3, run 49
Performing exp 3, run 62
Performing exp 3, run 14
Performing exp 3, run 31
Performing exp 3, run 48
Performing exp 3, run 61
Performing exp 3, run 13
Performing exp 3, run 30
Performing exp 3, run 47
Performing exp 3, run 60
Performing exp 3, run 12
Performing exp 3, run 29
Performing exp 3, run 59
Performing exp 3, run 46
Performing exp 3, run 11
Performing exp 3, run 28
Performing exp 3, run 58
Performing exp 3, run 45
Performing exp 3, run 10
Performing exp 3, run 27
Performing exp 3, run 44
Performing exp 3, run 57
Performing exp 3, run 9
Performing exp 3, run 26
```

```
Performing exp 3, run 43
Performing exp 3, run 56
Performing exp 3, run 8
Performing exp 3, run 25
Performing exp 3, run 55
Performing exp 3, run 42
Performing exp 3, run 7
Performing exp 3, run 24
Performing exp 3, run 54
Performing exp 3, run 41
Performing exp 3, run 6
Performing exp 3, run 23
Performing exp 3, run 53
Performing exp 3, run 40
Performing exp 3, run 5
Performing exp 3, run 22
Performing exp 3, run 39
Performing exp 3, run 52
Performing exp 3, run 4
Performing exp 3, run 21
Performing exp 3, run 38
Performing exp 3, run 3
Performing exp 3, run 20
Performing exp 3, run 37
Performing exp 3, run 73
Performing exp 3, run 72
Performing exp 3, run 2
Performing exp 3, run 19
Performing exp 3, run 36
Performing exp 3, run 71
Performing exp 3, run 1
Performing exp 3, run 18
Performing exp 3, run 35
Performing exp 3, run 70
Performing exp 3, run 69
Performing exp 3, run 80
Performing exp 3, run 79
Performing exp 3, run 85
Performing exp 3, run 84
Performing exp 3, run 89
Performing exp 3, run 88
Performing exp 3, run 68
Performing exp 3, run 78
Performing exp 3, run 83
Performing exp 3, run 87
Performing exp 3, run 67
Performing exp 3, run 77
Performing exp 3, run 82
Performing exp 3, run 86
Performing exp 3, run 66
Performing exp 3, run 76
Performing exp 3, run 81
Performing exp 3, run 65
Performing exp 3, run 75
Performing exp 3, run 92
Performing exp 3, run 91
Performing exp 3, run 74
Performing exp 3, run 95
Performing exp 3, run 94
Performing exp 3, run 90
Performing exp 3, run 98
Performing exp 3, run 97
Performing exp 3, run 93
Performing exp 3, run 96
Performing exp 3, run 100
Performing exp 3, run 99
```

Showing Results

```
figure(1); clf; hold on;
colorSet = varycolor(4);
for i=1:3
    lineHandles(i) = plot(p(i).meanBestFitness,'-','LineWidth',2,'Color',...
        colorSet(i,:));
    plot(p(i).meanMeanFitness,'--','Color',get(lineHandles(i),'Color'));
end
legend(lineHandles,name,'Location','NorthWest')
xlabel('Function Evaluations');ylabel('Mean Square Error');grid on;
%set(gca,'XLim',[0 2500]);
title('Parameter Effects')
```



```
nEvaluationPoints = 256;

for i=1:3
    nacaNumber = p(i).nacaNumber;
    nacafoil= create_naca(nacaNumber,nEvaluationPoints);
    figure(i+1);
    [foil, nurbs] = pts2ind(p(i).bestSolution,nEvaluationPoints);
    plot(nacafoil(1,:),nacafoil(2,:), 'LineWidth', 3);
    hold on;
    plot(foil(1,:),foil(2,:), 'r', 'LineWidth', 3);
    plot(nurbs.coefs(1,1:end/2),nurbs.coefs(2,1:end/2),'rx', 'LineWidth', 3);
```
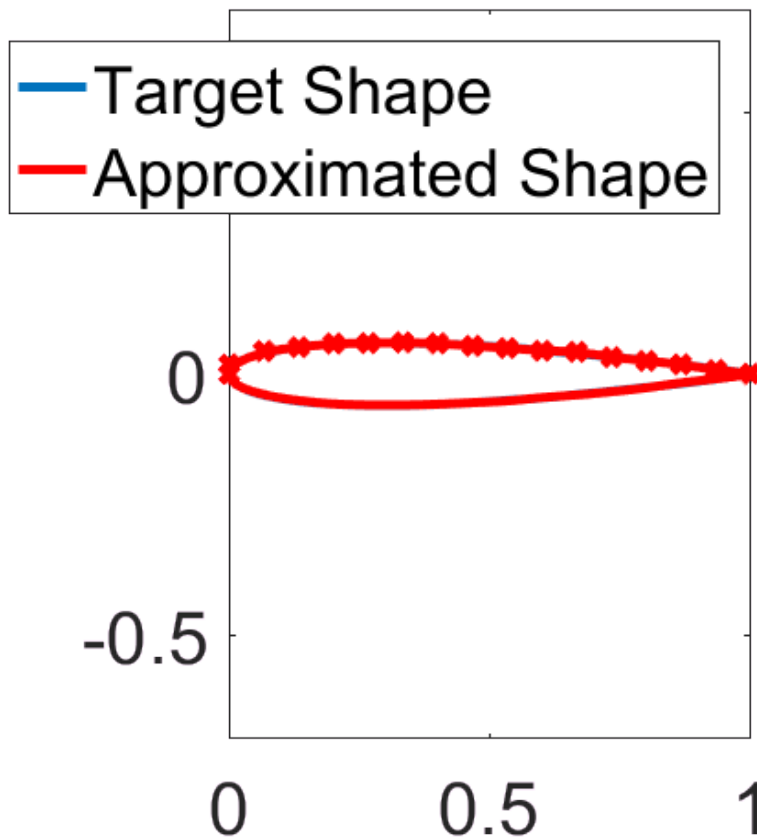
```
    axis equal;
    axis([0 1 -0.7 0.7]);
    legend('Target Shape', 'Approximated Shape');
    ax = gca;
    ax.FontSize = 24;
    drawnow;
    title(name{i});
    hold off;
end
```
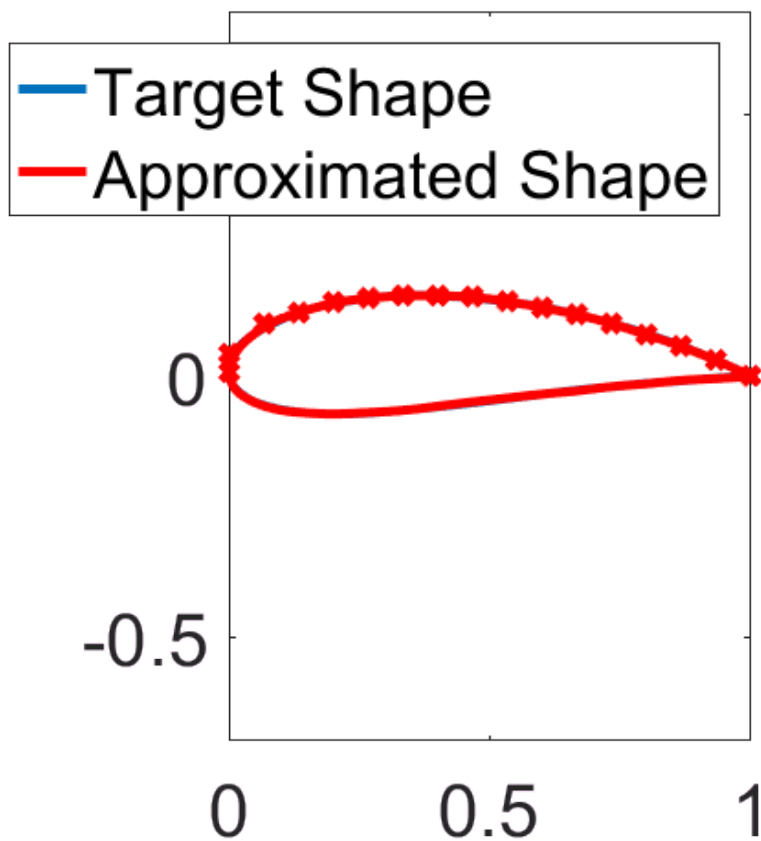
Warning: Integer operands are required for colon operator when used as index
Warning: Integer operands are required for colon operator when used as index
Warning: Integer operands are required for colon operator when used as index
Warning: Integer operands are required for colon operator when used as index
Warning: Integer operands are required for colon operator when used as index
Warning: Integer operands are required for colon operator when used as index

NACA 0012

NACA 5522

Target Shape
Approximated Shape

9735