Department of Aerospace Engineering
IIST, Thiruvananthapuram
Multi-disciplinary Optimisation (AE 496)

9:30AM-12:30PM
24/11/2017
(D4)

Maximum Marks: 50

Note:

1. All questions are compulsory.
2. Clearly state all the assumptions/approximations in the derivations/answers.
3. Diagrams that are not legible will not be graded. Extra credit will be given for clear and concise answers.

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1. Draw an XDSM for the IDF and MDF architectures for the standard aeroelasticity optimisation problem. Aeroelasticity optimisation problem is the optimisation of a *flexible* wing (characterised by design variables $x \in \Re^n$ with the objective of maximising the aerodynamic efficiency ($E = \frac{C_L}{C_D}$) using a gradient optimiser. Gradient calculation is performed using central finite difference method. Assume a global set of constraints (from both the aerodynamics and structures discipline) $g(x) \leq 0$. Clearly identify the coupling variables that you are using between the two disciplines. [6]

2. (a) Write a short note on need for the distributed MDO architectures over the monolithic MDO architectures. [2]

   (b) Draw a tree of various optimisation algorithms available for a designer. All the names of the optimisation algorithms that we mentioned (even though not studied) during the course should be mentioned. All the algorithms with similar characteristics should be bunched together and should be labeled as such. [3]

3. A CFD calculation is performed over an aircraft defined by n design parameters. The CFD solution thus obtained is post-processed to calculate m objective functions of interest (like lift, drag, pitching moment etc.). Assuming that the computational cost of one CFD run is C, write down the computational cost of the entire Jacobian matrix calculation for forward step finite difference, central finite difference, complex step method and the adjoint method. [4]

4. (a) Computer simulations of flow over an airfoil are deterministic in nature. Multiple CFD runs with same parameters (mesh-size, convergence criteria, turbulence model etc.) are expected to yield the same lift values. Hence, it is not reasonable to use least squares fit (which is a non-interpolating fit) to generate surrogate models for such cases. Comment. [2]

   (b) Write down the basis functions to be used for a second order regression fit for design variables $x = [x_1 \; x_2 \; x_3]^T$. [2]

Student's name:

Question 4 continues on the next page. . .

(c) A linear regression model is fit in $x \in \Re^n$ for an objective function f using N datapoints where $N > n + 1$. Gradient descent technique was used to obtain the regression coefficients w_i. w_i thus obtained are unique. Comment. [2]

(d) What is aliasing error? How is it overcome during sampling for surrogate models? [2]

5. Given an objective function $f(x) = \frac{1}{2}x^T Ax - b^T x,\ x \in \Re^n$, prove that the conjugate gradient method reaches the optima x^* in n iterations. [6]

6. (a) What is the primary advantage of MOEA algorithms over the gradient based scalarisation algorithms? [2]

   (b) Point out any two disadvantages of VEGA with respect to NSGA algorithms. [2]

7. (a) What are the various parameters and operators of particle swarm optimisation? Discuss their influence on the performance of the algorithm. [3]

   (b) Describe atleast two different types of “scaling” and “selection” methods used in genetic algorithms. [3]

   (c) On what basis will you select a specific scaling method and a selection method for your application? [2]

   (d) Also discuss the significance of crossover and mutation probabilities on the performance of the algorithm. [2]

8. (a) Given $y = f(x)$, derive the equations for μ_y and σ_y using first order moment method of uncertainty propagation in terms of μ_x and σ_x. [3]

   (b) Compare four points of relative advantages and disadvantages of moment methods and Monte Carlo method for uncertainty propagation. [4]