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Choice of Design Variables

1. Overview
2. Mesh Points
3. Hicks-Henne Functions

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Choice of Design Variables

Overview 1

- Choice of design variables is one of the most important decisions in optimal design.
- Proper choice of design variables requires understanding of the flow physics and the type of design variables that affect the objective function.

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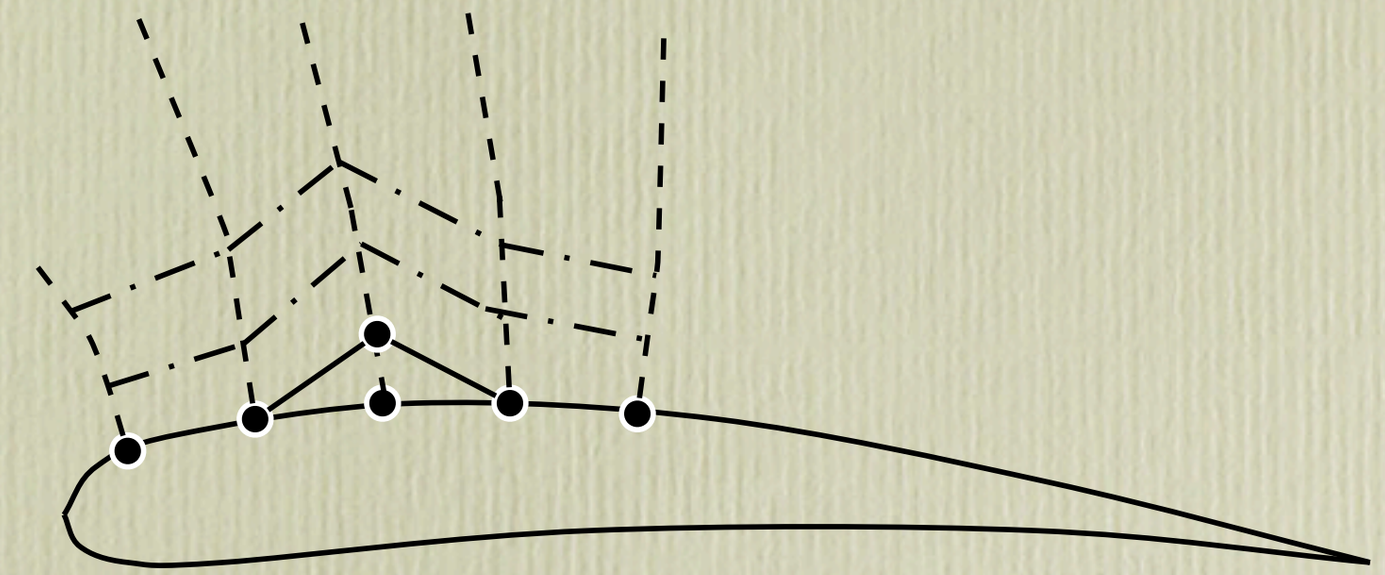
Choice of Design Variables

Mesh Points 1



- Ensures that there is no restriction on the attainable geometry.
- If every surface mesh point is used, then complete design space containing the solution that achieves the global minimum is attainable.
- Gradients can be computed cheaply since $\delta S_{i,j}$ is only non-zero for points along the perturbed grid line.

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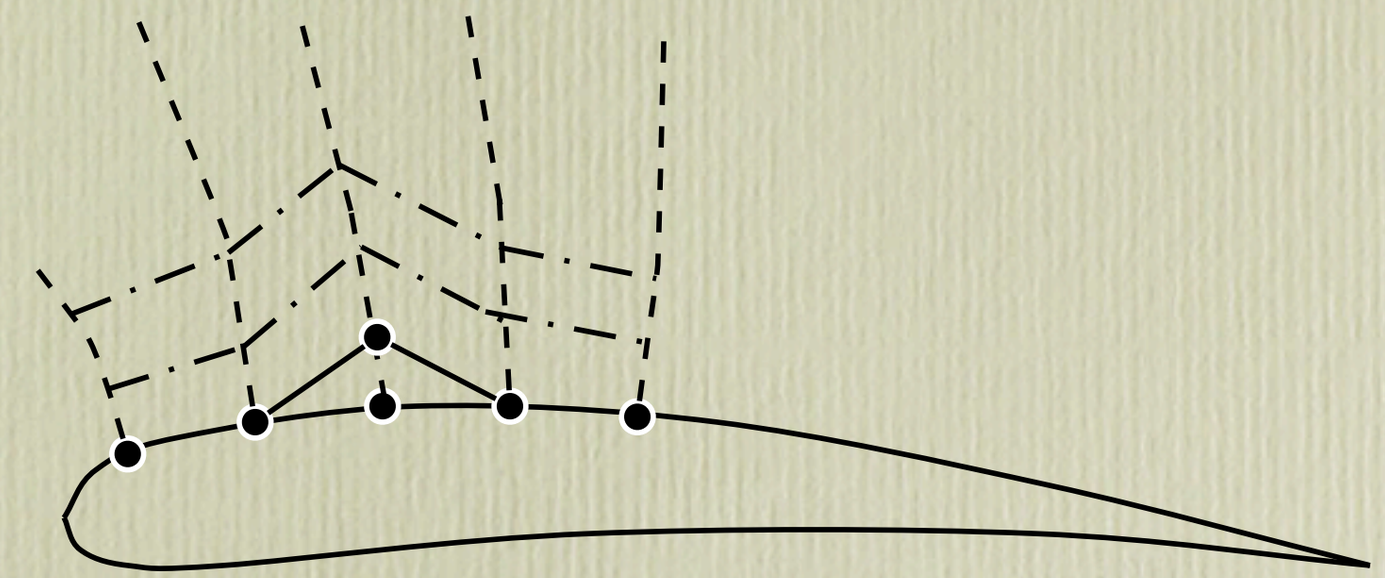
Choice of Design Variables

Mesh Points 2



- If all surface mesh points are used, then method is COSTLY for 3D Viscous problems.
- Final geometry may not be smooth, due to gradients may contain high frequency modes.
- In an aerospace company, the final design stage requires the submission of the aircraft CAD lines. BUT CAD geometry may not match surface mesh geometry !!!

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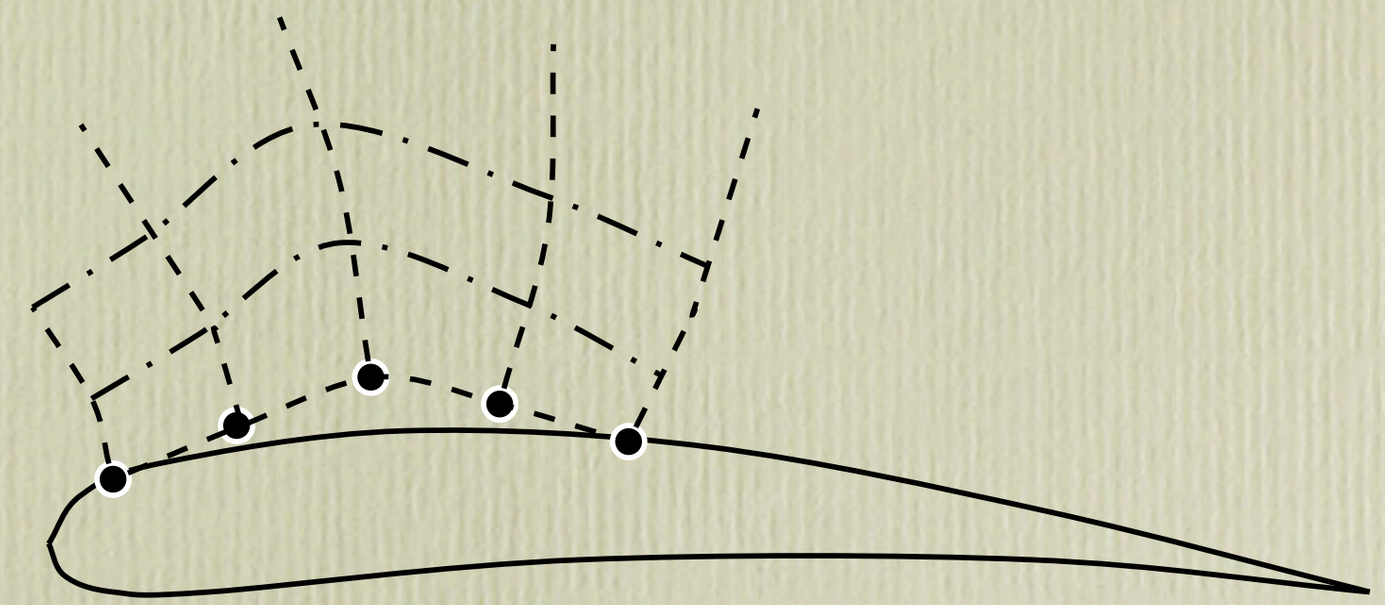
Choice of Design Variables

Hicks-Henne Functions I



- Parameterize design space with set of smooth functions.
- Computed gradient remains smooth, and thus successive surface geometries in the design process remains smooth.
- Only a few Hicks-Henne sine bump functions are required to provide an acceptable span of the design space thus requiring fewer design variables.
- Bumps can be placed in the CAD geometry instead of the surface mesh, however, re-meshing can be costly.

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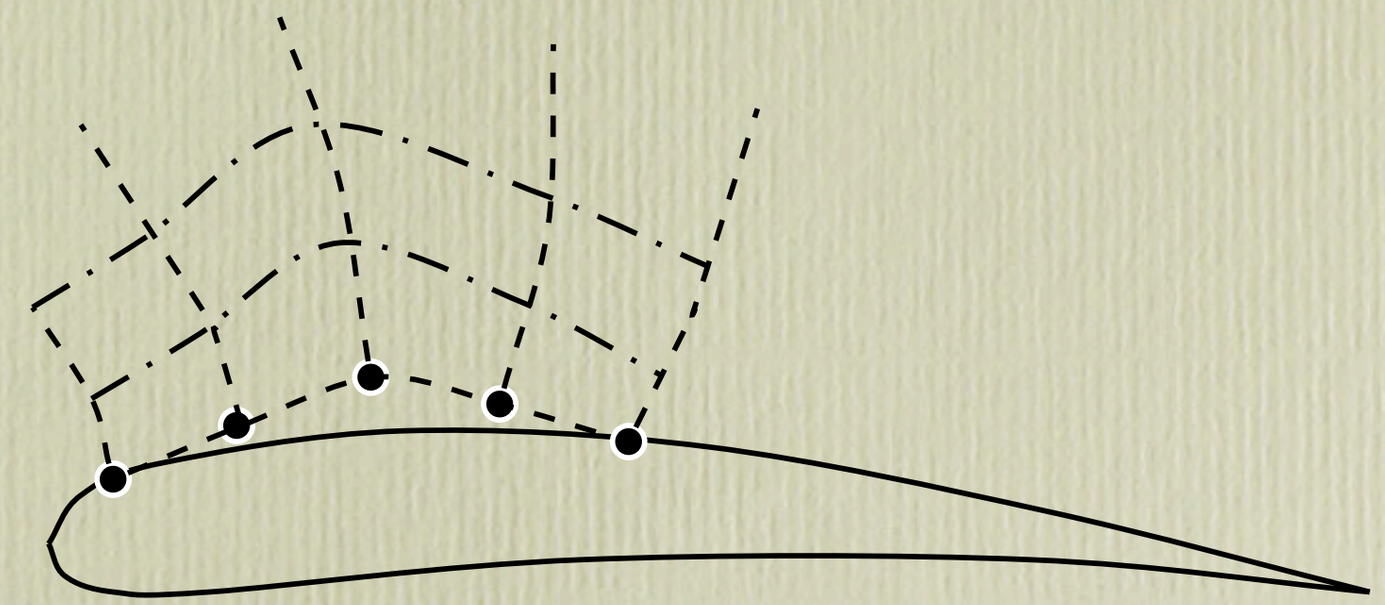
Hicks-Henne Functions 2



$$b(x) = a\left[\sin\left(\pi x^{\frac{\log 5}{\log t_1}}\right)\right]^{t_2} \qquad \text{for} \;\; 0 \leq x \leq 1$$

- a maximum bump magnitude
- t_1 locates the maximum point of the bump
- t_2 controls the width of the bump
- This flexibility allows one to place the bump at strategic points where a redesign is preferred while leaving other parts of the airfoil intact.