Condensation Based Finite Element Model Reduction Strategy for Structural Optimization Problems

KAKADE Ishaan
Under Guidance of:
CONIGLIO Simone
MORLIER Joseph

Institut Supérieur de l'Aéronautique et de l'Espace
SUPAERO

General Problem Description

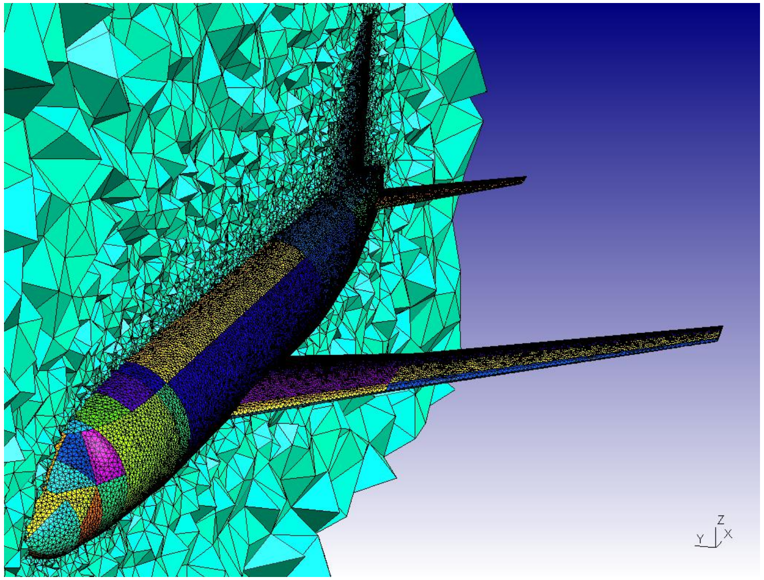


Figure 1: Mesh of an A319

Degrees of Freedom

- Topological optimization processes use the whole finite element model as the design space (all nodes or degrees of freedom)
- We would like to reduce that number by 60 – 70%.
- Would also like to retain the fidelity of the problem with the full mesh analysis

General Problem Description

Brief Finite Element Analysis on a Bracket

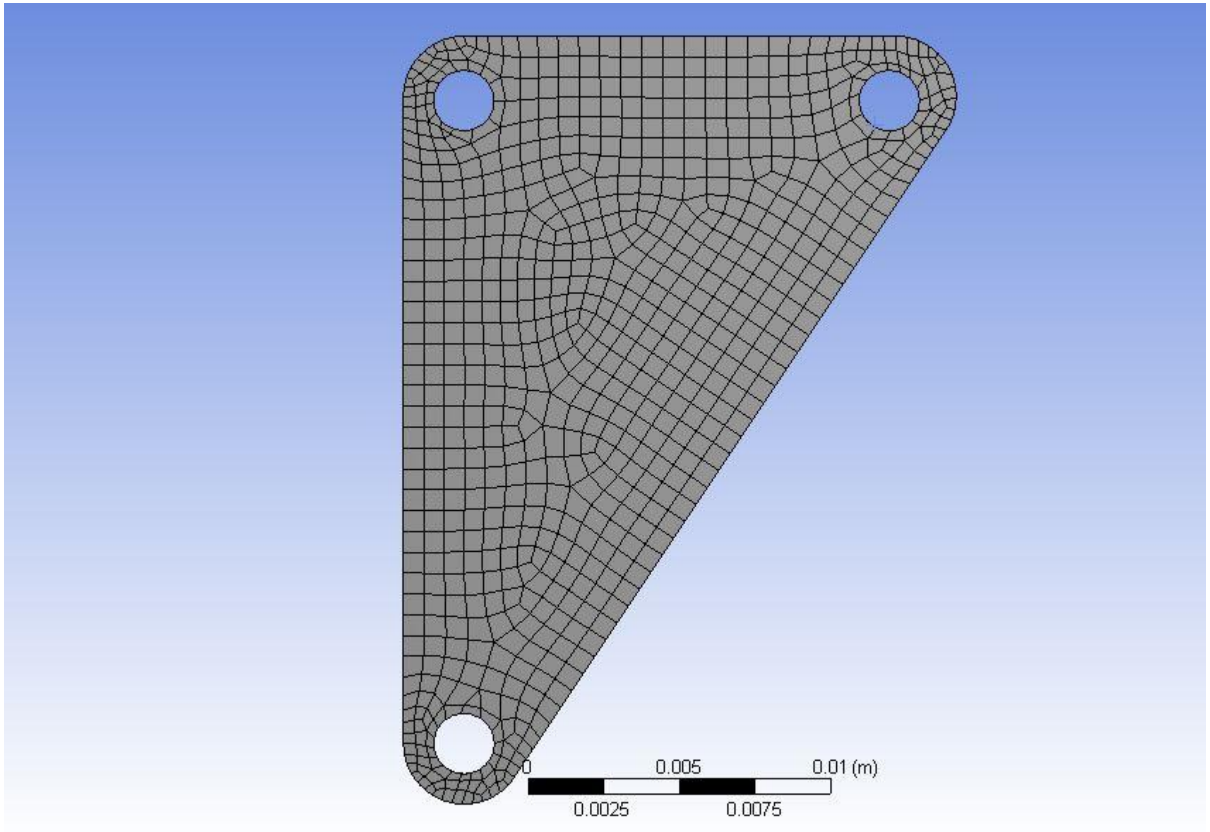


Figure 2: Mesh of Bracket using Proximity – Curvature Approach

General Problem Description

Brief Finite Element Analysis on a Bracket

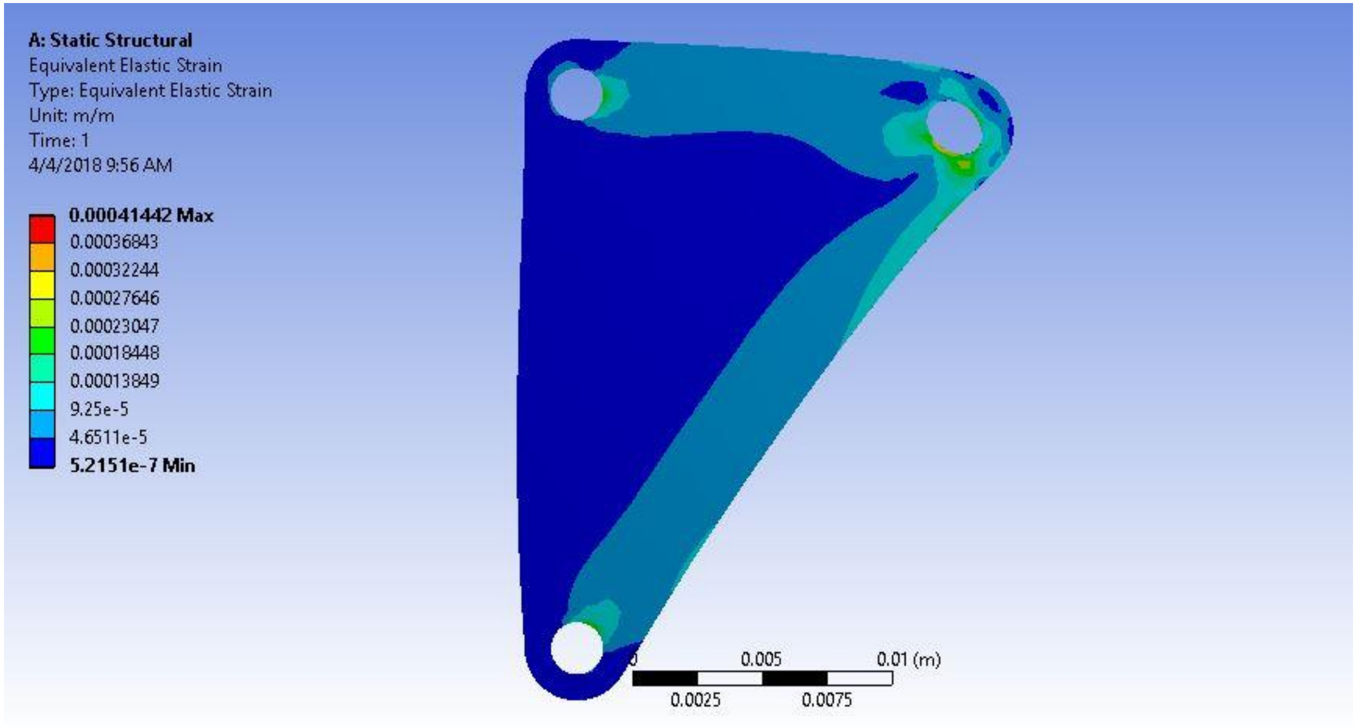


Figure 3: von – Mises Stress Analysis with Bearing Loads

General Problem Description

Brief Finite Element Analysis on a Bracket

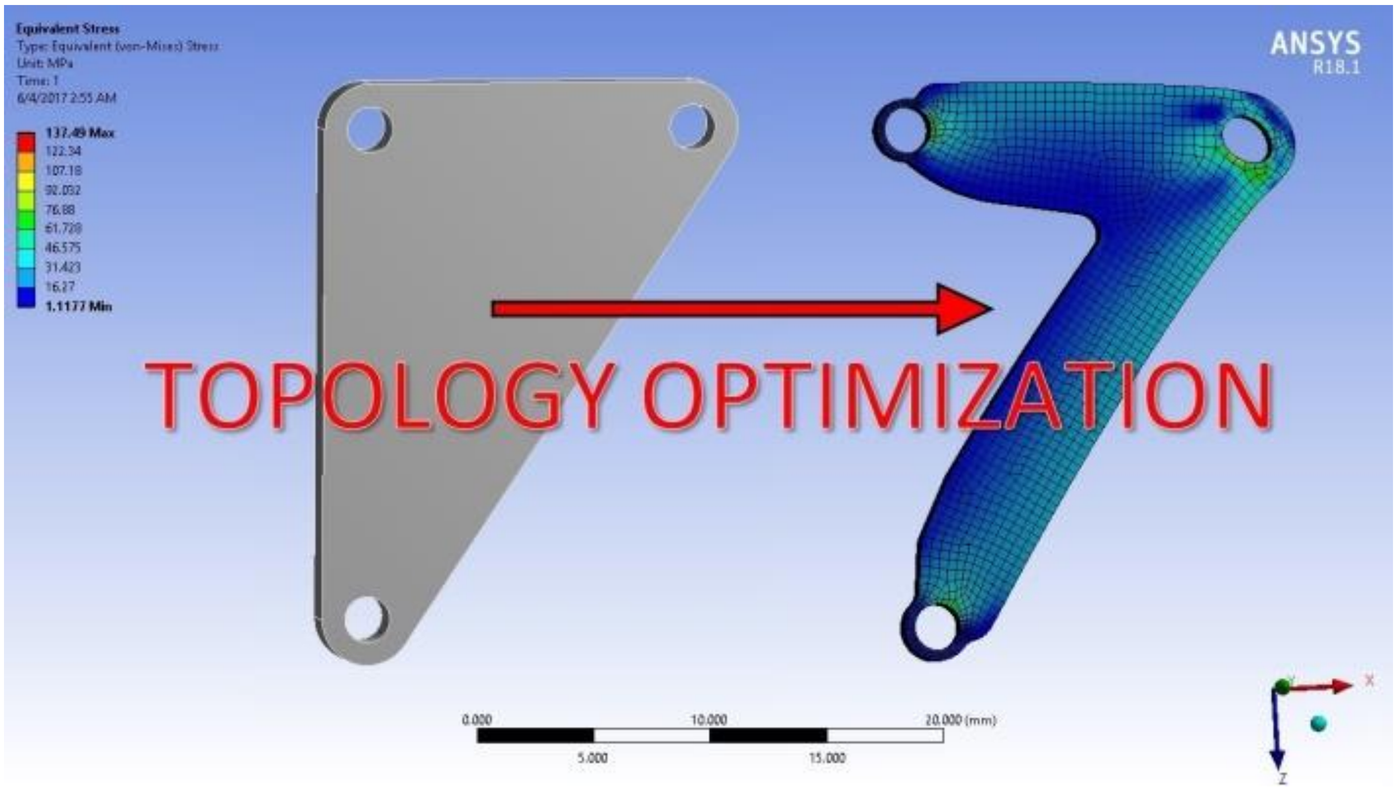


Figure 4: Topology Optimization

Project Goals

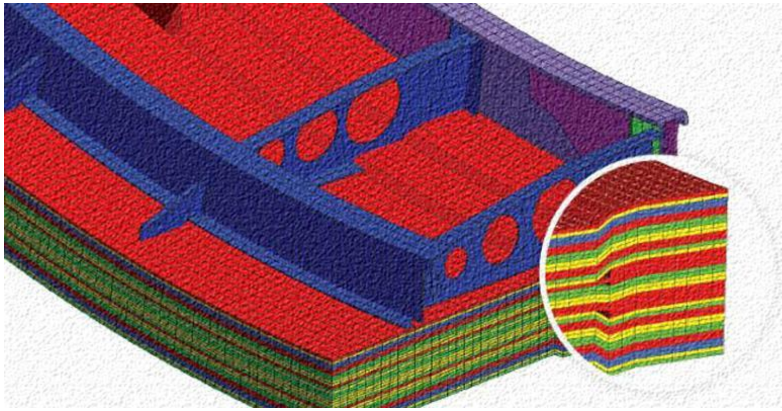


Figure 5: Mesh of a composite Fuselage

Primary Goal

The overall goal of this project is to establish a strategy to reduce the complexity of a finite element problem used for optimization purposes by the use of some (or a combination) of reduction strategies to suppress some degrees of freedom while maintaining full response.

Secondary Goal

To homogenize the material properties of a structure given that more and more aerospace structures now use composite materials with highly discretized material properties across geometries. [1]

State of the Art

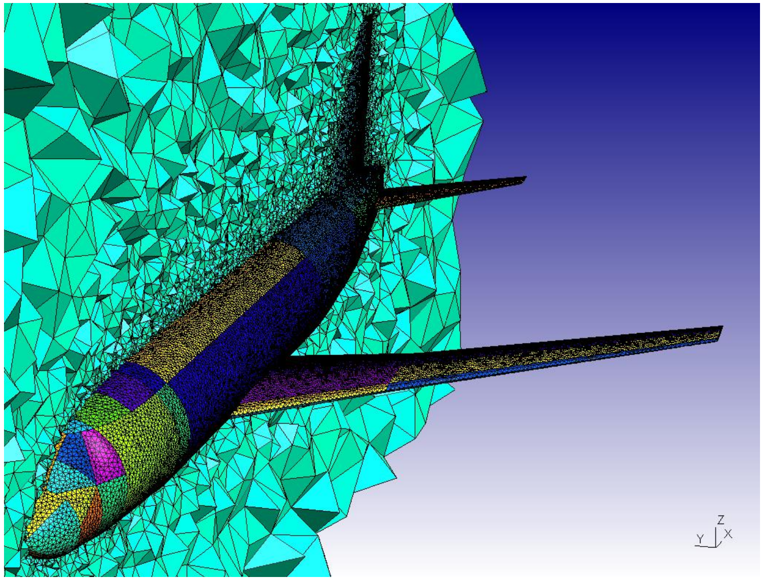


Figure 6: Mesh of an A319

Structural Condensation

- It is the technique used to reduce the number or nodes in the domain of an F.E.M. model.
- Classical condensation does this by finding approximate relationships between various degrees of freedom.
- The nodes are split as “Master Nodes” and “Slave Nodes”.

State of the Art

Static Condensation

Dynamic Condensation

Zu-Qing Qu and Zhi-Fangfu's condensation method [2]

Project Milestones

1. Literature Review (Contd.)

2. Choice of Condensation Modelling Technique

3. Choice of Topology Optimization Technique

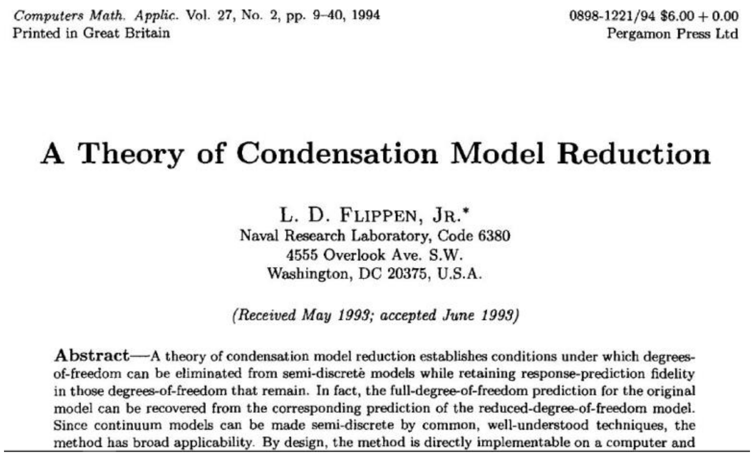
4. Implementation of Working Code

5. Testing of Code on Sample Cases

Key Challenges

- Choosing appropriate assumptions for mass distributions.
- Choosing our decision variables carefully so as to not lose out important regions in the structure to optimize.
- Building a code that is reasonably fast.

References*


Computers Math. Applic. Vol. 27, No. 2, pp. 9–40, 1994
Printed in Great Britain
0898-1221/94 $6.00 + 0.00
Pergamon Press Ltd

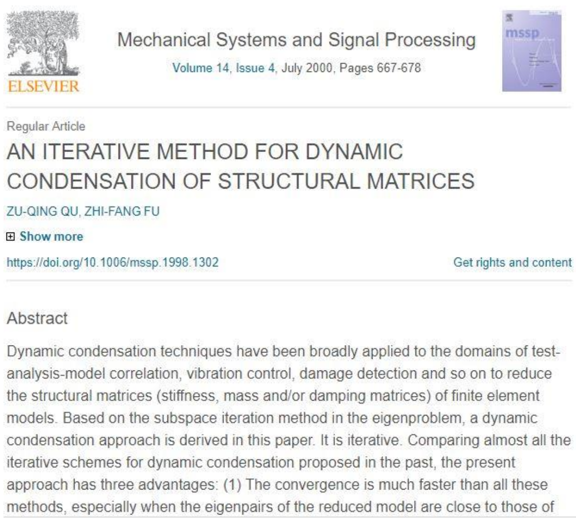
A Theory of Condensation Model Reduction

L. D. Flippen, Jr.*
Naval Research Laboratory, Code 6380
4555 Overlook Ave. S.W.
Washington, DC 20375, U.S.A.

(*Received May 1993; accepted June 1993*)

Abstract—A theory of condensation model reduction establishes conditions under which degrees-of-freedom can be eliminated from semi-discretè models while retaining response-prediction fidelity in those degrees-of-freedom that remain. In fact, the full-degree-of-freedom prediction for the original model can be recovered from the corresponding prediction of the reduced-degree-of-freedom model. Since continuum models can be made semi-discrete by common, well-understood techniques, the method has broad applicability. By design, the method is directly implementable on a computer and

Figure 7: Excerpt of paper by Flippen


ELSEVIER
Mechanical Systems and Signal Processing
Volume 14, Issue 4, July 2000, Pages 667-678

Regular Article

AN ITERATIVE METHOD FOR DYNAMIC CONDENSATION OF STRUCTURAL MATRICES

ZU-QING QU, ZHI-FANG FU

Show more

https://doi.org/10.1006/mssp.1998.1302

Abstract

Dynamic condensation techniques have been broadly applied to the domains of test-analysis-model correlation, vibration control, damage detection and so on to reduce the structural matrices (stiffness, mass and/or damping matrices) of finite element models. Based on the subspace iteration method in the eigenproblem, a dynamic condensation approach is derived in this paper. It is iterative. Comparing almost all the iterative schemes for dynamic condensation proposed in the past, the present approach has three advantages: (1) The convergence is much faster than all these methods, especially when the eigenpairs of the reduced model are close to those of

Figure 8: Excerpt of paper by Zu-Qing Qu

References

[1] L.D. Flippen Jr, (1994), A Theory of Condensation Model Reduction, *Computers Math. Application, Vol. 27* (No. 2), pp. 9 - 40.

[2] Zu-Qing Qu, Zhi-Fangfu, (2000), An Iterative Method For Dynamic Condensation Of Structural Matrices, *Mechanical Systems and Signal Processing*, Vol. 14 (No. 4), pp. 667 - 678.

Thank you!

Questions/Suggestions?

05/04/2018 | **KAKADE Ishaan**

isae
Institut Supérieur de l'Aéronautique et de l'Espace
SUPAERO