

# Topology Optimization using the material density as a level set function

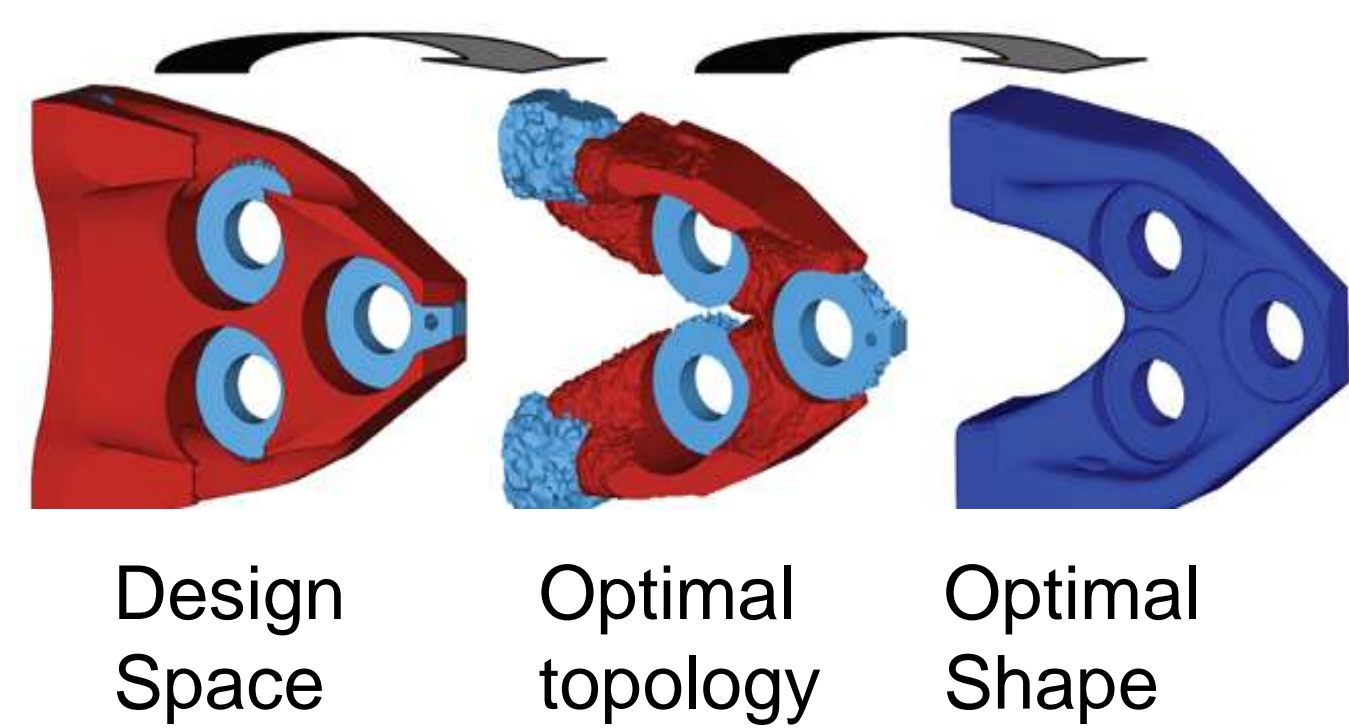
Luis F. Fernandez A.

Dr. Georges Fadel, Dr. Paolo Guarneri  
Clemson University, SC



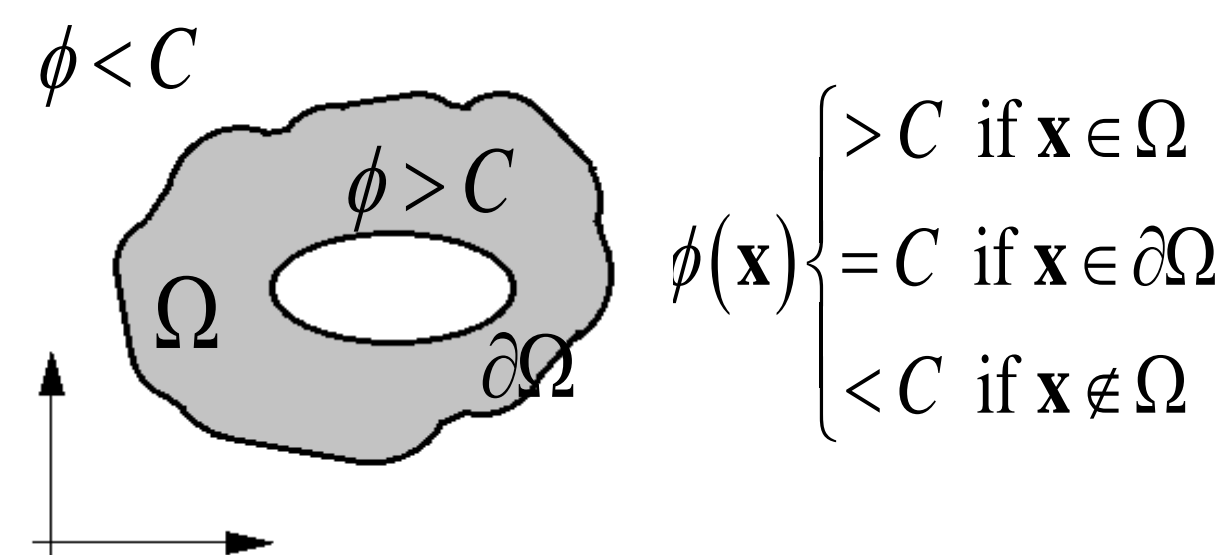
## INTRODUCTION

- Optimization → powerful design tool.
- Objective of Topology Optimization (TO) → Best material distribution at the early stage of the design process.



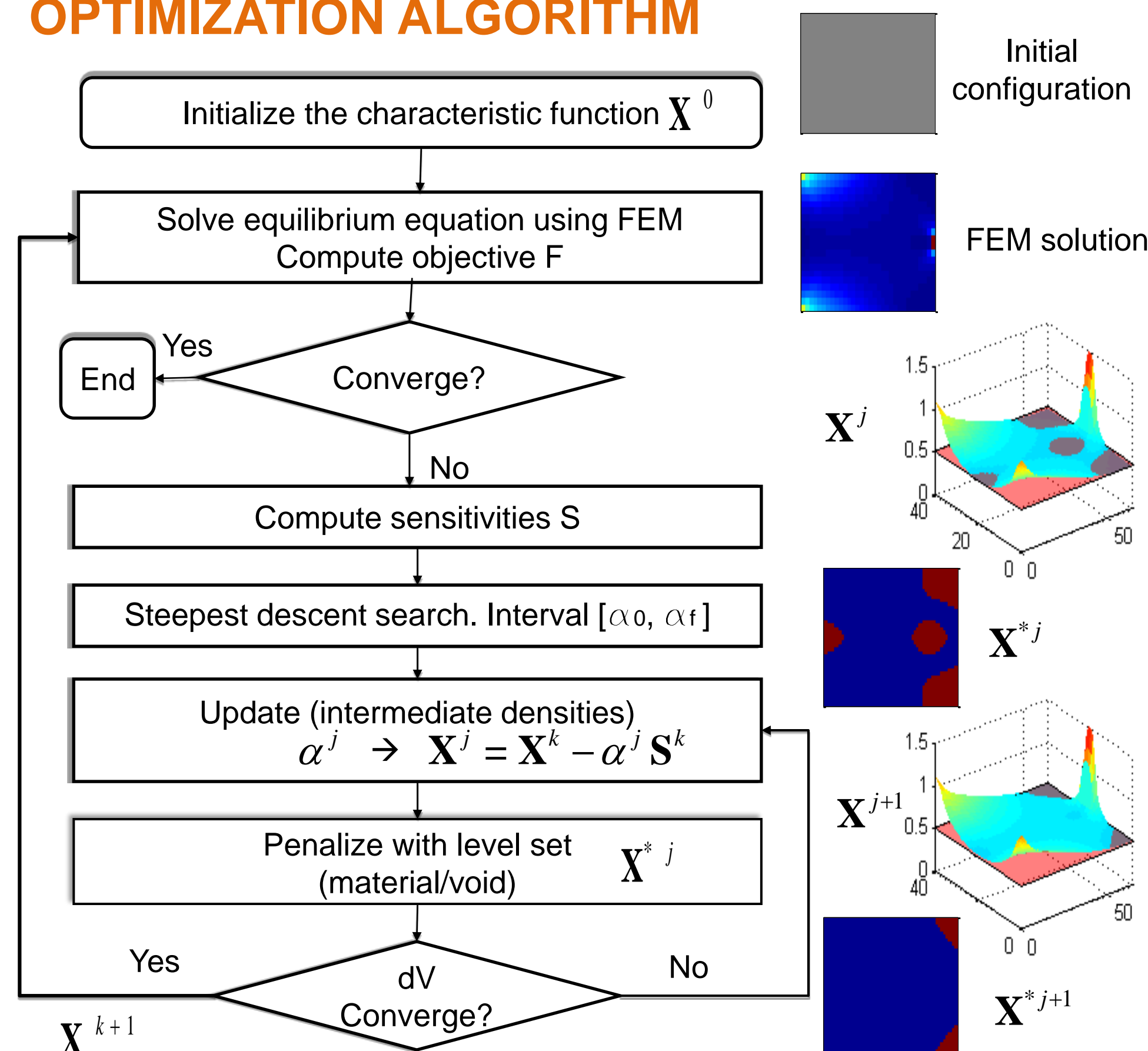
**Figure 1: TO.**  
Source:  
<http://www.altairproductdesign.com>

- Level sets model material void distribution → can be used in TO.



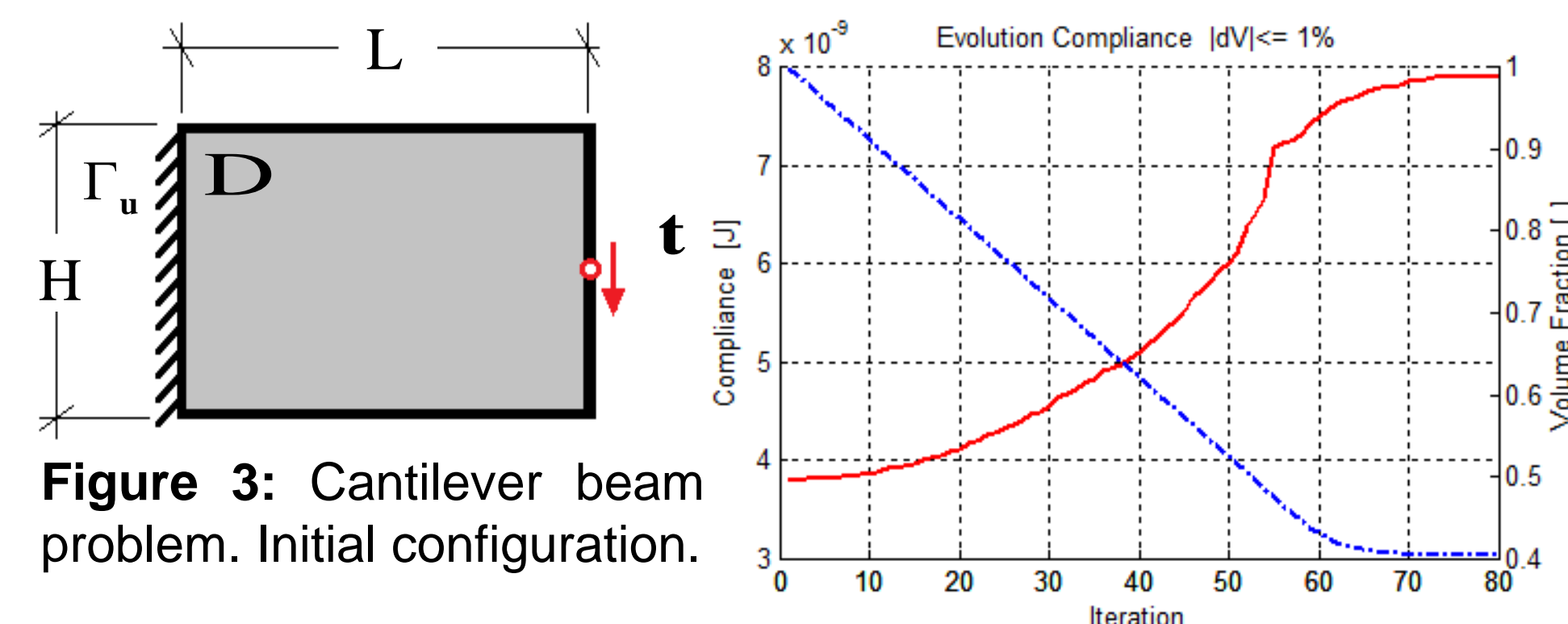
**Figure 2:** Schematic geometry representation using a level set function.

## OPTIMIZATION ALGORITHM

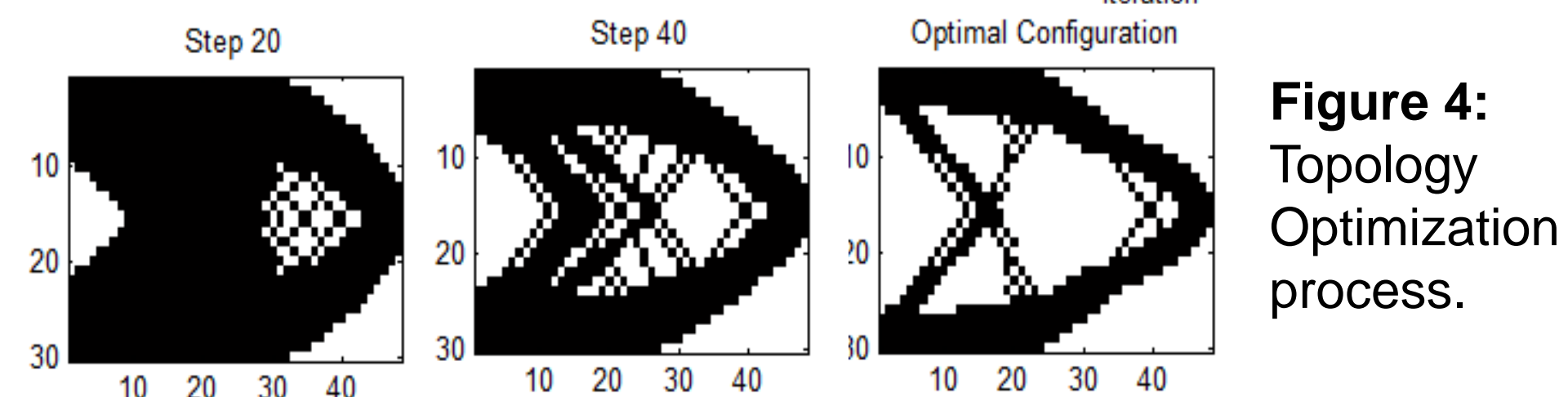


## RESULTS

- Problem: Minimize the compliance (Maximize the stiffness) with a volume ≤ 40%.

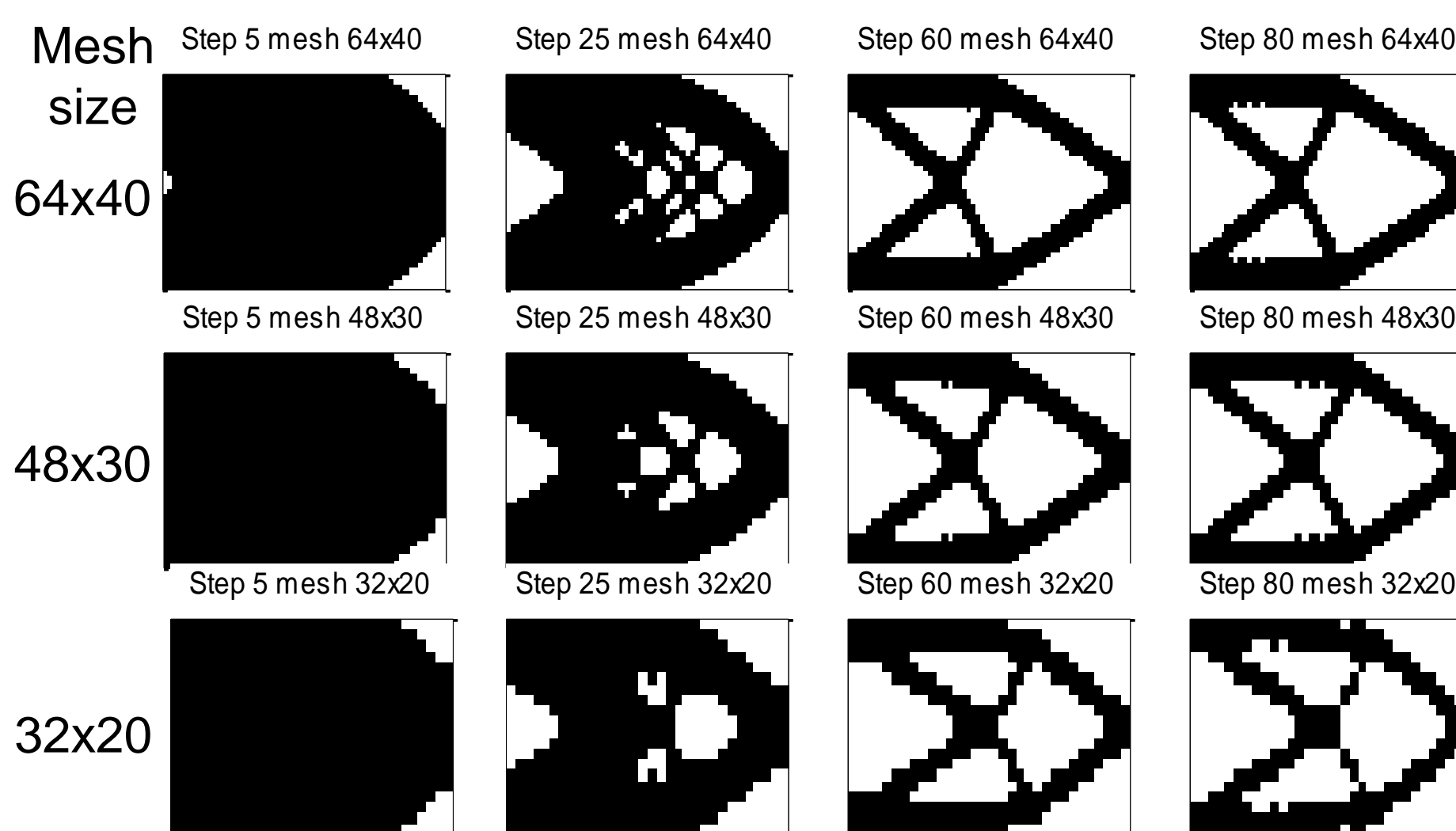


**Figure 3:** Cantilever beam problem. Initial configuration.

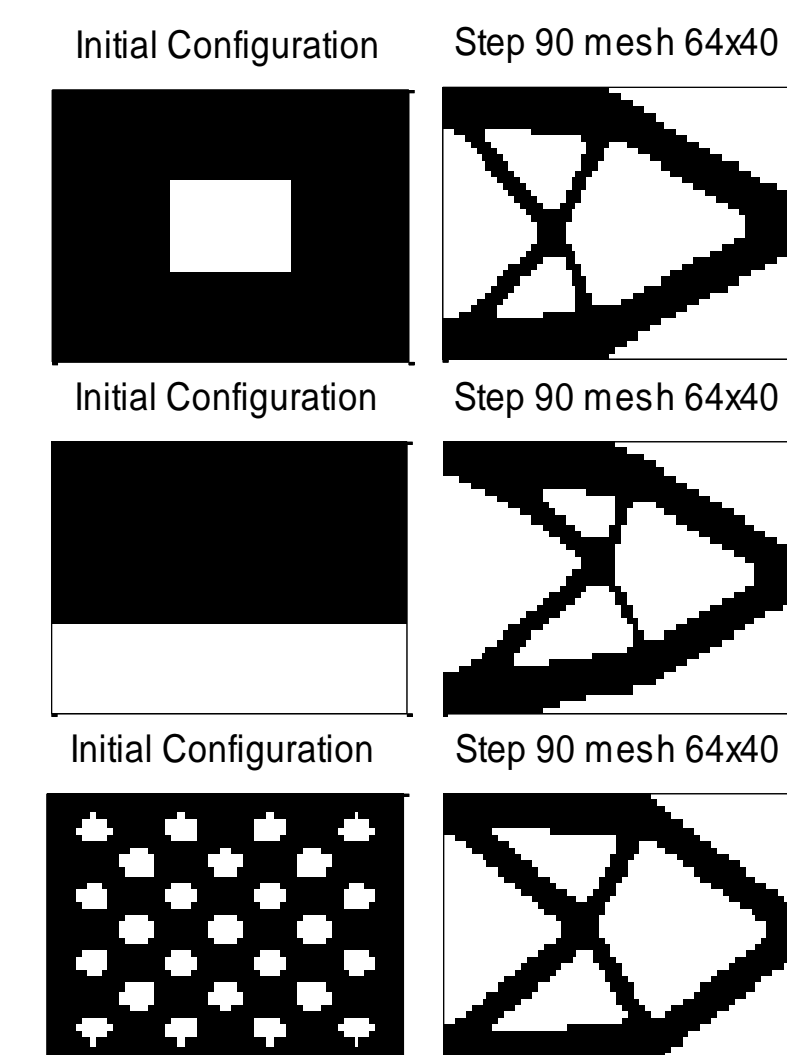


**Figure 4:** Topology Optimization process.

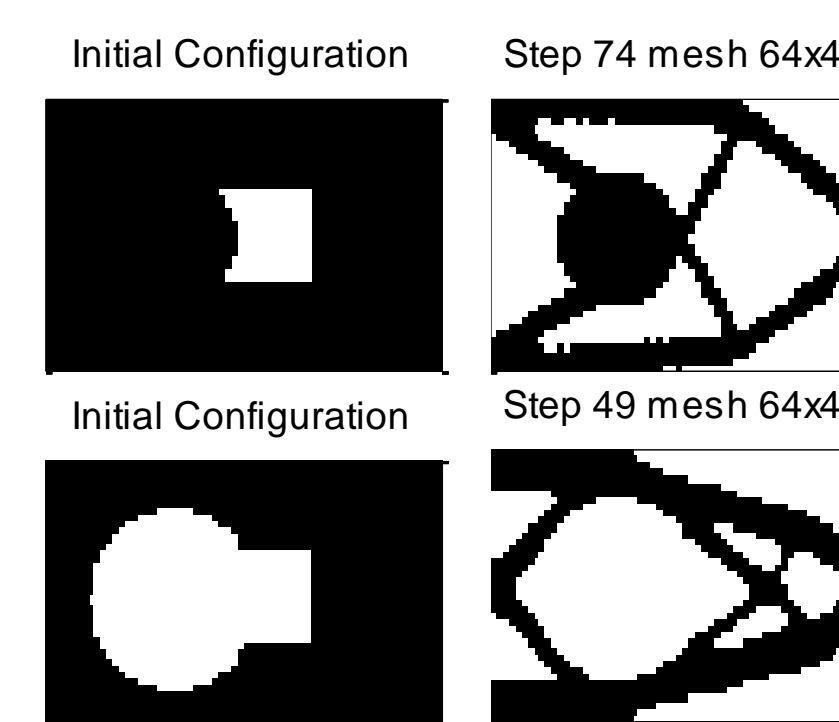
- Improvement with sensitivities filter



**Figure 5:** Topology optimization process for different mesh size elements.



**Figure 6:** Different initial conditions with similar optimal configurations



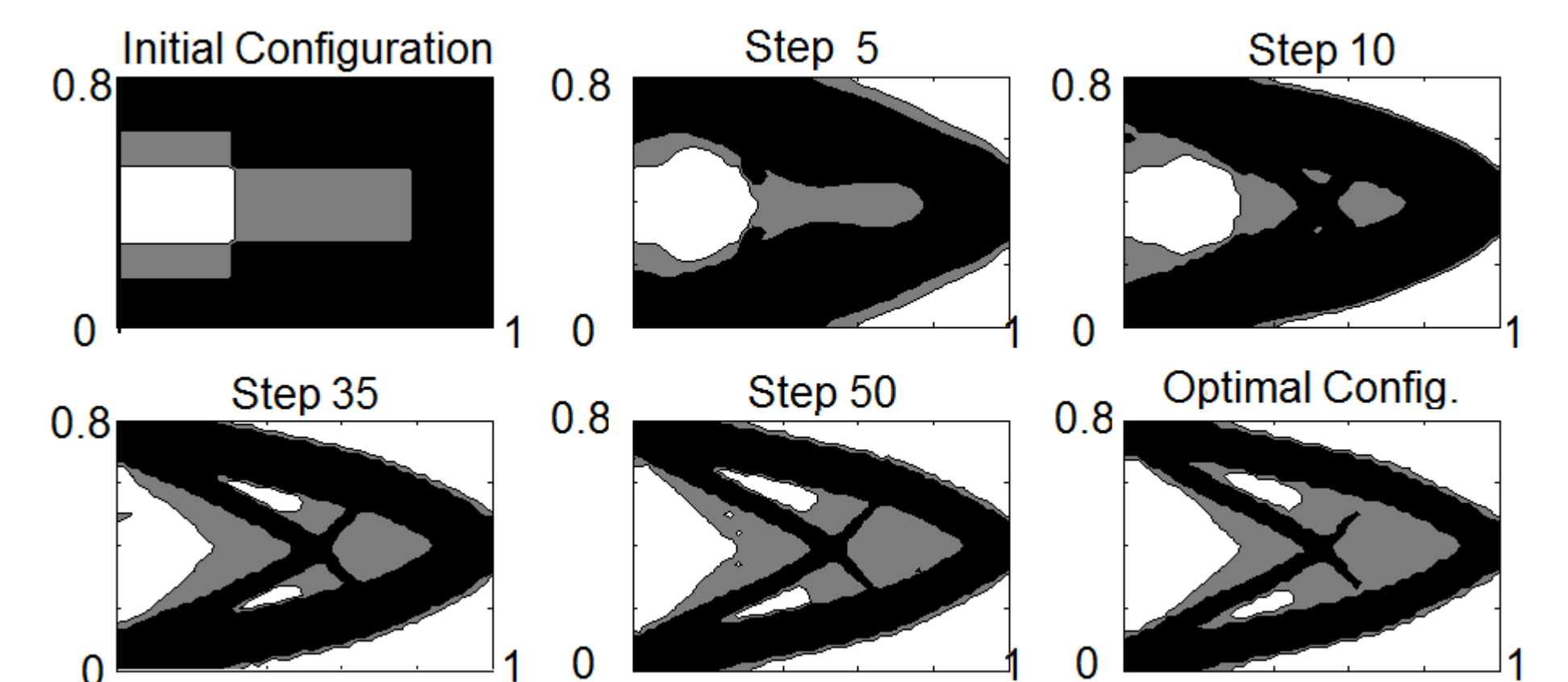
**Figure 7:** Active and Inactive Regions

## CONCLUSIONS

- The use of the level set penalization properly help to decide what elements should be removed/added.
- Filter the sensitivities and/or boundary control helps to obtain optimal configuration with low dependency on the mesh size and the initial configurations.
- This method is more efficient than traditional level set methods in terms of computational cost due to the use of a simple evolution equation (Steepest descent direction).
- The use of the material density as level set function can handle very general objective functions and the sensitivities can be conveniently computed.

## Current work:

- Multi-material design.



**Fig. 8:** Cantilever beam using 2 materials and void. Initial, intermediate and optimal configurations.

- Target material properties.



## References:

- Bensoe M, Sigmund O, Topology Optimization. Theory, Methods and Applications, Denmark: Springer, 2003.
- Yamada T., Izui K, Nishiwaki S., Takezawa A., "A topology optimization method based on the level set method incorporating fictitious interface energy.," *Compu. Methods Appl. Mech, Engrg.*, 2010.