
Contents

Abstract	vii
Resumen	ix
Resum	xi
Preface	xiii
Acknowledgements	xv
I Thesis report	1
1 Introduction	3
1.1 Motivation	3
1.2 Objectives	5
1.3 Outline of the thesis	7
2 State of the art	9
2.1 Structural optimization	9
2.1.1 Topology optimization	9
2.1.2 Shape optimization	12
2.1.3 Hybrid optimization	13
2.2 Immersed boundary methods	15
2.2.1 Cartesian grid Finite Element Method (<i>cgFEM</i>)	15
2.2.1.1 Topology optimization in <i>cgFEM</i>	18
2.3 Advanced techniques for high-dimensional data analysis	19
2.3.1 Manifold learning	19

2.3.2	Topological data analysis	21
2.3.3	Optimal transport	24
3	Contributions	27
3.1	Advances in structural optimization: topology optimization and hybrid Techniques	27
3.1.1	Benchmark problem	28
3.1.2	Improvement strategies in topology optimization	32
3.1.2.1	Voxel-type independent integration mesh	32
3.1.2.2	Solution-based refinement strategies	34
3.1.3	Hybrid optimization	38
3.1.3.1	STEP 1: Topology optimization	40
3.1.3.2	STEP 2: The ML-based TO-SO interface	42
3.1.3.3	STEP 3: Shape optimization	45
3.2	Knowledge-driven design generation	48
3.2.1	Benchmark Problem	49
3.2.2	Methodology	50
3.2.2.1	Geometrical characterization	50
3.2.2.2	Topological characterization	51
3.2.2.3	Modifications in LLE to consider geometry and topology	52
3.2.2.4	Optimal transport-based interpolation to recover dimensionality	55
3.2.2.5	Methodology to propose suitable designs	57
4	Closure	61
4.1	Summary	61
Bibliography		63
II	Articles	71
Paper A:	Improvement in 3D Topology Optimization with h-adaptive refinement using the Cartesian Grid Finite Element Method	73
Paper B:	Allying topology and shape optimization through machine learning algorithms	125
Paper C:	Manifold learning for coherent design interpolation based on geometrical and topological descriptors	171