

Preface

Over the past few years while studying for my doctorate, many times when explaining what my research consisted of, the reaction to my saying that I was “studying the topic of optimization”, was always the same: “Optimization of what?”. Moreover, it was always accompanied by a puzzled look on the part of the interlocutor. The first time I was rather surprised by such a question and look then, as time passed by, I become accustomed to them. In fact, I found it rather amusing to repeat the same old phrase to different people, irrespective of their age, education, social background or culture, and to be able to foresee their reaction and their answer. On my part, I tried to answer using the simplest words I could find, avoiding any technicality in order to be understood if possible: “Well—I replied—everything and nothing: I am studying the theory of optimization. It is a general approach, rather mathematical, that you can apply to any problem you like. In particular I am applying it to some test cases, mainly in the fields of thermodynamics and fluid dynamics”. However, with an even more puzzled look they seemed to say: “Are you kidding me?”. To my chagrin, I realized I had not been able to communicate to my listeners any understanding of what I meant. Neither I had any idea on how to explain things in a simpler way. It seemed optimization could not constitute a research topic in itself, being necessarily associated to something more practical. Worse still, it was as if in “optimization” no “theory” was needed since just some common sense was enough, thus, there was nothing to study! I had the overall impression that most people think that optimizing something is a sort of handicraft job in which one would take an object, whatever it is, and with a long build-and-test approach, almost randomly, trying again and again, so would hopefully manage to improve its working. At other times it seemed to me that “optimization” and “design” were thought of as incompatible, with the field of interest of optimization limited to some sort of management issue for industrial processes.

For my part, I never thought of it in this way when I started my doctorate, these questions and ideas not even coming to mind when optimization was proposed as

research. Probably I was more oriented towards the idea of studying the theory, perhaps making a contribution to the scientific community in terms of some novel, and hopefully significant optimization algorithm. But how sound was my reaction original? Nevertheless, was my reaction the best thing to do? After all, in the world of optimization theory there are plenty of good algorithms, based on very bright ideas. Was adding one more to the list what was really needed?

As my research progressed I began to understand what an extremely powerful instrument optimization was. Despite this, it still had to break out and spread within the technological and scientific worlds, for it was still not properly understood. Perhaps the people I had spoken to over the last few years were right, for even though they may have had a limited turn of mind over the issue, was my mind any less limited despite my research over the topic? I was still focused on the mathematical aspects (“theory”) while they were focused on the practical aspects (let us call them “design”). The fact was that theory and design were too far away from each other and still had to meet. This was what was missing and what was worth dealing with in my research: the creation of a link between the theory of optimization and its practical outworking in design. It had to be shown that such a link was possible and that optimization could be used in real-life problems.

Optimization can be a very powerful instrument in the hand of the designer and it is a highly interdisciplinary topic which can be applied to almost any kind of problem; despite this is still struggling to take off. The aims of this research work are to show that using optimization techniques for design purpose is indeed viable, and to try to give some general directions to a hypothetical end user, on how to adopt an optimization process. The latter is needed mostly because each optimization algorithm has its own singularities, being perhaps more suitable for addressing one specific problem rather than another. The work is divided into two parts. The first, focuses on the theory of optimization and, in places, can become rather complicated to understand in terms of mathematics. Despite the fact that these are things which can be found in several books on optimization theory, I believe that a theoretical overview is essential if we are willing to understand what we are talking about when we deal with optimization. The second part addresses some practical applications I investigated over these years. In this part, I essentially try to explain step-by-step the way in which a number of optimization techniques were applied to some test cases. At the end, some conclusions are drawn on the methodology to follow in addressing different optimization problems.

Finally, of course, I come to the acknowledgments. Since I would like to thank too many people to be able to name them individually, I decided not to explicitly mention anybody. However, I would like to thank my family, my supervisors and the colleagues who shared the doctorate adventure with me at the Department of Mechanical and Civil Engineering of the University of Modena and Reggio Emilia and during my short stay at the School of Engineering and Design at Brunel University. A special thanks must be given to all those hundreds of people that,

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