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Inside the optimization practice: some provocative reflection from an actor-network theory perspective[1]

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Abstract. One of the most important stages in a many areas of engineering and applied sciences is modeling and the use of optimization techniques to increase the quality and performance of products or processes. The contention of this paper is that actor-network theory (ANT) approach, a provocative line of thought, offers a new and radical stance for understanding the optimization process and that it is able to grasp its ontological complexity. The starting point is to look at the optimization process as a *complex socio-technical practice* where material things, human beings, theories as well as representation intermingle in a complex becoming of negotiations and mutual reproduction.

Keywords: Optimization, Actor-Network Theory, Evolutionary Computing, No Free Lunch Theorems.

1. Optimization: opening the black-box

Generally in literature, with the term "optimization" is related to (the output of) a mathematical technique or algorithm used to identify the extreme value of an arbitrary objective function through the manipulation of a known set of variables and subject to a list of constraining relationships. These mathematical and algorithmic techniques are the focus of the majority of optimization literature. In this paper we want to look at this issue from a more abstract stance. In this context "optimization" also has a more general usage referring to a system of physical objects (computers, machines) abstract ideas and people combined for discovering and verifying the best implementable solution to high-dimensional design problems in a broad range of engineering and sciences applications. In this more general usage, optimization can be conceptualized as a (complex) system composed with different sub-systems is a multiphase process, in which applying a particular maximization algorithm or technique is just one step. The success or the failure of the optimization process can depend on a single step (right implementation of a algorithm e. g. the "maximization-algorithm application step") or for a not correct interaction of the different parts at different levels of organization (fig. 1). In this sense it is better to talk about an "optimization process" as a *practice* that can be characterized as a complex, multi-actor with an emergent nature set of procedures.

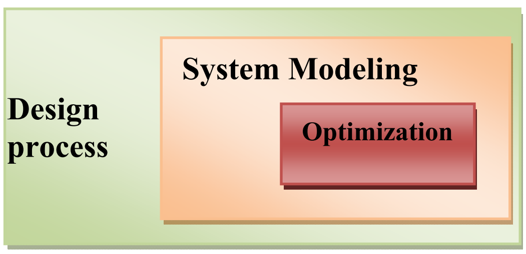

Fig 1. The traditional *locus* for optimization in the industrial practice

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In order to get new insight about how the optimization practice works successfully or fails, how it is performed, and how it is intergraded in broader organizational processes both in industry as well as in the academia, it can be fruitful to invest in crossing theoretical borders and to capitalize on progress made in other disciplines and fields of studies [1,4,7,8,9]. In order to enable the development of new direction and new fields of research, this paper tries to develop a new attitude on the optimization practice by applying actor-network theory to this field.

2. Background: the basic tenets of Actor-Network Theory (ANT)

The purpose of our paper is to grasp insights about the optimization practice using ANT and to point out relatively unexplored research potential. ANT should be viewed as part of a wider "practice turn" within different disciplines. Practice-based approaches to the optimization process place an emphasis on understanding the *practices* through which the process emerges out of the unpredictable, embodied, and materially mediated, *lifeworlds*, of practitioners themselves, together with representation of "best practice" ideals, abstractions, theorems and disciplinary authority. The push to gain conceptual distance from an image of the optimization process as an *automatic machine-like algorithm application* and to put value on the unpredictable emergence of social and material interactions that influence outcomes. Emerging during the mid-1980s, ANT was a body of knowledge situated within the sociology of science and technology. The literature on ANT contains many concepts but their interpretation and application vary and reviews of ANT are numerous. Canonical starting points can be ([2], [5], [6]). Here we will give a brief elementary introduction to the basic elements of the framework. A network is often described in terms of nodes and links. In ANT the nodes are called *actants*, any entity that interacts with other actors or serves as an intermediary between actors and that *performs* moulding locally and/or globally the configuration of the network. In ANT actants can be real, concrete entities but also abstract objects like ideas, representation etc. Summarizing actants can be: i) texts, theories, ideas: especially how network associations are strengthened through citations and references; ii) technical artifacts; iii) human beings: and the relationships derived from position, skills, authority and responsibility. In the vocabulary of ANT, they are 'enrolled' into a network through a process called "translation". Translation involves bringing together seemingly quite different entities, for example, Darwin's theory of evolution and optimization techniques. Let's consider the example of the *evolutionary computing* to clarify this point. The basic idea of the evolution theory is that the individuals with a greater "fitness to the environment" have a greater probability of surviving and a greater probability of winning the fights for mating. In such a way the genetic content of the best individuals will be more and more present in the following generations, since it will be transmitted by the offspring.

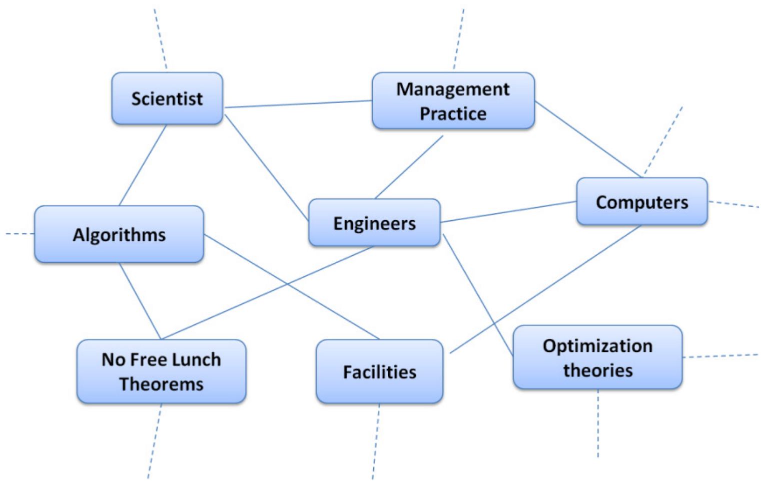

Fig 2. A representation of the *optimization web* as conceived in ANT

This has inspired the development of *genetic algorithms*, proposed by Holland in the 1960s. Nowadays Biology-inspired algorithms play an important part of computational sciences since they are applicable to a wide variety of optimization problems: discrete, continuous, or even mixed parameters without any a priori assumptions about their continuity and differentiability [12]. In terms of ANT this translation of a domain into another is resulted in a specific assemblage of networks evolution that was not only unpredictable, but truly creative, with the production of emergent organization and innovative outcome solutions that ultimately transformed the optimization practice. From an ANT standpoint, the wide diffusion of this or that optimization methods at the expense of others is not only and necessarily a matter of their intrinsic properties, but the results of their subsequent translations and incorporations in powerful *external* networks. Following the main actors, and tracking associations and translations it is possible to decrypt how 'artefacts' – materials as well as pieces of embodied knowledge – are translated into 'facts' and successively into 'black boxes', which, at least for a while, 'act as one' [1]. From an established terminology, biology-inspired algorithms and the more general nature-inspired algorithms (NIAs) are classes of heuristic algorithms based on populations of objects. Even if they still lack a strong theoretical foundation able to understand or predict its behavior other than a superficial level, NIAs are conceptually simple and it is relatively easy to develop program code for any kind of application. This can partly explain the speed of practical and empirical diffusion of these techniques virtually in every area of applied sciences far outside the field of computer sciences. At the same time in the academic environment the "publish or perish" *mantra* seems accountable for the proliferation of new variants of NIAs based on the phenomenology of some natural phenomena at the point that nowadays new papers on the topic are countless. How the actor-network temporary coagulate and rationalized this social fact into a meaningful mainframe will be briefly considered in section 4.

3. Optimization as actor-network

The standpoint trough which we can to grab hold of a better understanding of the optimization process from an ANT perspective stems from some initial premise about the ontological status of an actor-network. Actor and networks mutually produce each other's: that`s why we can't separate them and we talk about an irreducible *actor-network*. An example can be fruitful to explore this; a particular a multiobjective genetic algorithm code on one given problem can be used for determine a Pareto optimal set or as a pre-optimization tool to explore the surface response of a given mono-objective fitness function. The role of the actant here (for example an implementation of the NSGA-II algorithm) in the network can acquire very different meanings, be more or less useful. So different set of parameters can be used and the role and performance of the algorithm will be different. In the optimization actor-network a variety of entities are enrolled as, and mobilised as, actants into the optimization process: algorithms, theoretical approaches, computer experts, statistical packages, etc. (fig. 2). Even the apparently abstract fact of framing a problem in optimization terms is not innocent at all. The kind of entities and actors that are enrolled or not enrolled into the network and how they are enrolled is a characteristic of the *context*, where "context" here must be interpreted in a broader way as the situated character of social reality, involving coexistence, connections and 'togetherness' as a series of associations and entanglements in time–space (for a general discussion see [7]). For example in the case of industrial product design optimization the reason for choosing a given class of optimization strategies (a genetic algorithm instead of particle swarm a Monte Carlo based method for example) can be connected to the local availability of expert knowledge, constrained to the utilization of a given machine or proprietary software or imposed from some *bias* internal to a given epistemic community. There are a number of resources freely available on Internet and it is common nowadays to adapt pre-existing codes instead of creating them *ex-novo* for time saving reasons and this in turn is connected to higher level organizational settings (availability of time and resources) that together can affect the final outcome. It is also important to notice that actants enrolled in the network can be actor-networks themselves, e.g. in the shape of project management practice, external companies pressure, etc. organizing their own heterogeneous complexity. There will therefore be a tension in the interactions between the actor-networks. Usually in the industry the optimization activity is just a part, a sub-module, of a broad modelling process that is in itself a sub-module of the product design process. In this sense more actor-networks enter in a complex process of interaction\negotiations. An artifact like computer design software is produced from a certain set of ideas of how the design process is organized inside the company and can include or not an optimization module that can constrain to a given extent the possibility of the users in a way that can be unpredictable and contingent. Here, the notion of *contingency* is central to ANT. The accomplishment of a certain actor-network in a given configuration for a given time is always just one among (infinitely) many possible outcomes. Contingency then means that actor-networks emerges out of delocalized choices, there is no higher-level plan prescribing the mobilisation of the network and there is no platform for making these choices rationally, because the network self-establish its own schema of rationality.

4. Bringing about optimization facts: the role of the *performance*

An ANT stance forces a kind of analysis that is *performance* centred. Performance is looking at reality "in the making". It is connected to the *coming true* of social meaningful routines goings-on through active human and non-human expression. Methodologically, field observations, ethno-methodological and text analytical approaches are commonly employed in the decryption of the actor-network constellation. Performance not only involves a process of the relational construction of identity; the term is widened to include all sorts of practices that are involved in the human project of (re)creating *optimization actions* in conditions that can be defined as negotiations. Identity, e.g. the institutional role of human actor involved, is one important facet in this relational interaction. For example the depiction of the optimization task from the point of view of an engineer can be different from the point of view of a computer scientist or a mathematician. The former can be more interested on the computational efficiency response whereas the seconds on a deeper understanding of the gap between theoretical underpinnings and actual outcomes of a given optimization approach. A statistician would assume a different approach too, focusing primary on how to acquire most information possible from sampled data and only subsequently thinking about the optimization problem. Those representations are continuously negotiated and a deep analysis of this can shed light on the successes or failures of the overall process. At the same time abstract entities can exert their agency too in a way that can remodel widely the actor-network. In the field of optimization a very good example given by the so called *No Free Lunch Theorems* or, to say it better, their *interpretations* inside the scholar community [3]. According to the most common understanding of NFLT there is no optimization method superior to others for all possible optimization problems. Moreover, an algorithm that performs well on one class of problems must perform *worse than random search* on all remaining problems. Running an algorithm on a small number of problems with a small range of parameter settings will not be a good predictor of that algorithm's performance on other problems, especially problems of a different typology. This theoretical result represents now an *obligatory passage point* [9] for every expert in the field that has to cope with and the interpretation of them and they have pervasive impact on routinely performance of the optimization process. According to some influential authors ([10] chapter 23 and [11] section 2.7) it is possible to derive the *practical implication* that produce actively and diffusely a *schema of rationality* for the daily work of optimization. For example Yang ([11], p. 26) wrote:

> "Even though, the NFL theorems are valid mathematically, their influence on parameter search and optimization is limited. For any specific set of functions, some algorithms do perform much better than others. In fact, for any specific problem with specific functions, there usually exist some algorithms that are more efficient than others if we do not need to measure their average performance. *The main problem is probably how to find these better algorithms for a given particular type of problem*[2]. […] The knowledge about the particular problem of interest is always helpful for the appropriate choice of the best or most efficient methods for the optimization procedure."

Similarly Wise wrote ([10], p. 213):

> "The No Free Lunch Theorem argues that it is not possible to develop the one optimization algorithm […] this must sound very depressing […] Actually, quite the opposite is the case, at least from the point of view of a researcher. The No Free Lunch Theorem means that there will always be new ideas, new approaches which will lead to better optimization algorithms to solve a given problem. Instead of being doomed to obsolescence, it is far more likely that most of the currently known optimization methods have at least one niche, one area where they are

[2] My italics

> excellent. […] There will always be a chance that an inspiring moment, an observation in nature, for instance, may lead to the invention of a new optimization algorithm which performs better in some problem areas than all currently known ones."

So according to this interpretation, far from representing a *limiting* result, the NFL theorems offer one way to explain the adoption or diffusion of some techniques at the expense of other for a given class of problems and this embodies the *theoretical rationale* that fosters the never-ending research of improvement and new algorithms and whose agency – although with contextual negotiations variants - inform the everyday practice in industry and in the academic research.

5. Conclusions

This paper was supposed to be a cross-disciplinary effort in order to learn more about how optimization practice works, how it is performed, and how it produces outcomes and spaces. It is just a starting point in order to enable the development of new approaches and enlarge the way in which we usually look at the optimization from a different viewpoint. Scientists, researchers, engineers, and other practitioners, continuously everyday co-operate within communities of people and collection of things, ideas, theorems and techniques, building more or less coherent actor-networks that together re-create the optimization *phenomenon* and its effectiveness. To discover how they face and try to overcome resistance, how they try to conceal, define, hold in place, mobilize, and bring into play the juxtaposed people and things in the optimization practice, the researcher has to penetrate in the web of actions, routines and taken-for-granted assumptions that produce a meaningful whole.

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7. References

[1] A. Lagendijk and J. Cornford, Regional institutions and knowledge. tracking new forms of regional development policy. Geoforum, 2000, 31(2), 209-218. Elsevier.

[2] B. Latour. On recalling ANT. In: J. Law and J. Hassard, (eds) Actor-Network Theory and after. 1999, pp. 15-25. England. Oxford: Blackwell Publisher.

[3] D. H. Wolpert and W. G. Macready (Apr 1997): No free lunch theorems for optimization. IEEE Transactions on Evolutionary Computation,1999, 1(1), 1997, pp. 67–82.

[4] E. Noe and H. F. Alroe, Combining Luhmann and Actor-Network Theory to see Farm Enterprises as Self-organizing Systems Paper to be presented at: The Opening of Systems Theory, 2003, Copenhagen May 23-25.

[5] J. Law. "Notes on the Theory of Actor-Network: Ordering, Strategy and Heterogeneity." Systems Practice 1992, 5:3. pp. 79–93.

[6] M. Callon. "Some Elements of a Sociology of Translation: Domestication of the Scallops and the Fishermen of St. Brieuc Bay." In Power, Action, and Belief: A New Sociology of Knowledge? edited by J. Law., 1986, London: Routledge & Kegan Paul.

[7] N. J. Thrift. Spatial formations. 1996, London:Sage.

[8] R. van der Duim. Tourismscapes. An Actor-Network Perspective. Annals of Tourism Research, 2007, Vol. 34, No. 4, pp. 961–976.

[9] T. J. Barnes. Performing economic geography: two men, two books, and a cast of thousands. Environment and Planning A 2002, volume 34, pp. 487-512.

[10] T. Weise. Global Optimization Algorithms. Theory and Application. 2010. Available on internet at: http://www.it-weise.de/projects/book.pdf

[11] X. S. Yang, Engineering Optimization. An Introduction with Metaheuristic Applications, 2008, John Wiley & Sons, Inc., Hoboken, New Jersey.

[12] X. S. Yang, Review of Metaheuristics and Generalized Evolutionary Walk Algorithm, J. Bio-Inspired Computation, 2011, Vol. 3, No. 2, pp. 77-84.