

# Operations Research & Machine Learning

(*brief summary of main topics emerged during the parallel session of the 1<sup>st</sup> workshop of the Working Group on Practice of OR, Paris Saclay 16<sup>th</sup> Feb. 2018, collected by Matteo Pozzi<sup>1</sup>)*

Operations Research may be referred to as part of Artificial Intelligence (at least to the extent that both make use of data to provide support to decision making processes), which naturally includes Machine (& Deep) Learning (ML). Yet OR and ML are often seen as distinct and generally alternative approaches to Data-driven Decision Making, generally seen as part of the wider domain of Data Science.

A very simplistic view may assign to Data Science a predominant role on Descriptive Analytics, Machine Learning being the reference approach to Predictive Analytics, while Operations Research being referred to as the main approach to Prescriptive Analytics. Reality is obviously more complex than this!

We all see that Data Science is increasingly becoming “sexy” amongst Board Members in Business Organisations, with Machine Learning and Deep Learning emerging as buzz words that appeal both to non-specialists and general management, a recognition that has very rarely been shared by Operations Research.

Why is that? What can be learnt from this? Is this a threat or an opportunity for OR?

DS and ML often offer (relatively) quick tools that help users in making sense of the increasing mass of data that companies have to deal with, which is obviously an advantage with respect to OR, that generally starts from modelling of complex processes, representing an obvious barrier to non-specialists.

It is becoming increasingly common to embed OR into so-called “ML/AI projects”, yet it is extremely reductive to consider ML just as a fancy label to bring OR to the market:

- ML is creating increasing awareness of complexity and the importance of data in companies, bringing large masses of users into a more quantitative world, that is the natural setting to start OR projects; in this sense, ML is surely a key factor towards the creation of a mature market for OR; OR may use ML and DS techniques to visualize problems, analyse and cleanse data, and indeed to focus on what really matters to the customer (and maybe show the impacts of optimization projects – both potential and achieved);
- ML is capable of providing quick wins. OR often forgets about this, in favour of complex model, while it could learn that what works (and sells) does not necessarily need to be complicated. ML shows that success is built around the capacity to build small, scalable solutions that bring companies towards increasing levels of automatization. OR should aim for a similar pattern;
- ML approaches any issues just from the data it generates, without pre-conceived ideas. This is often not so with OR, that may be positively inspired by this fact (it is not

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<sup>1</sup> With valuable contributions by Joaquim Gromicho

so infrequent that OR concentrates on optimizing the wrong problem). May it not be that ML could support OR to become more flexible and adherent to reality?

- In fact, there are very interesting experiences where ML and OR are integrated in very smart ways. See, for instance, the work of Dimitri Bertsimas (MIT) and <http://www.cs.ubc.ca/labs/beta/Projects/SMAC/>;
- If the ML and OR communities are seen as “competitors” it is mostly linked to a cultural factor, while in fact most companies running advanced analytics projects employ multidisciplinary teams that cover both domains. The chance to integrate OR and ML in academic curricula (something that is already taking place in many Universities) should not be missed.;
- Lastly, it may be that OR may prove fundamental to “save” ML from illegality! The European Union’s General Data Protection Regulation (GDPR), which will come into force on May 25, 2018, introduces severe constraints regarding transparency of algorithms that will be allowed to take decisions. An overview of the consequences to the AI community can be found on <https://www.welivesecurity.com/2017/11/13/transparency-machine-learning-algorithms/> and on <https://arxiv.org/pdf/1606.08813.pdf>, while [https://en.wikipedia.org/wiki/General\\_Data\\_Protection\\_Regulation](https://en.wikipedia.org/wiki/General_Data_Protection_Regulation) points to the whole package of deliberations. There are lines of research (for instance <http://www.lnmb.nl/conferences/2018/programlnmbconference/Bertsimas-1.pdf>) which show how OR methodologies can produce predictive instruments that obey the law of interpretability and transparency while outperforming the ML champions.

In essence: time investigating how to integrate and leverage upon OR and ML is surely well spent!