

Deep Learning: a brief introduction

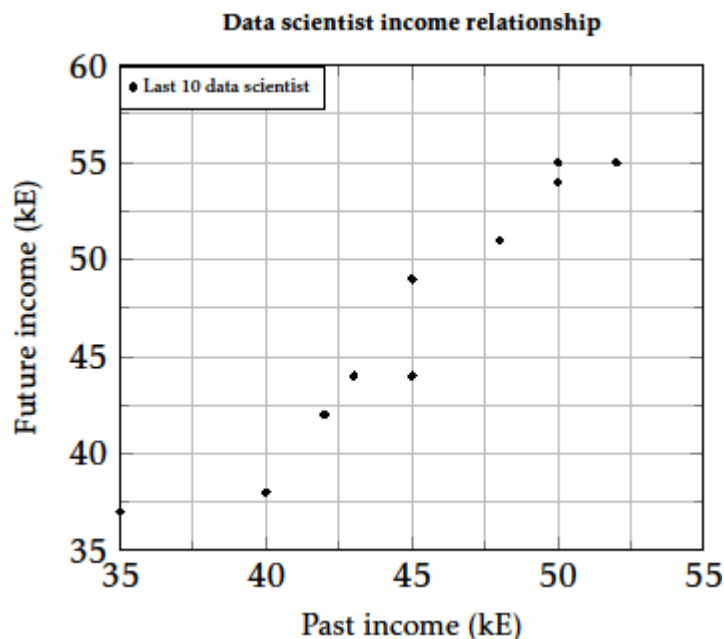
1) Machine Learning

What is **Deep Learning**? To answer this question, one needs to step back even more and ask: what is **Machine Learning**?

Let's say that you are a data science head hunter, trying to evaluate if one of the data scientists in your address book is asking too much for his future income (it's been three months now and you haven't yet managed to find him a company). To figure this out, you have some data on the previous 10 data scientists that you managed to get hired. This data includes among other things the previous yearly income that they perceived (before you found them a new job).

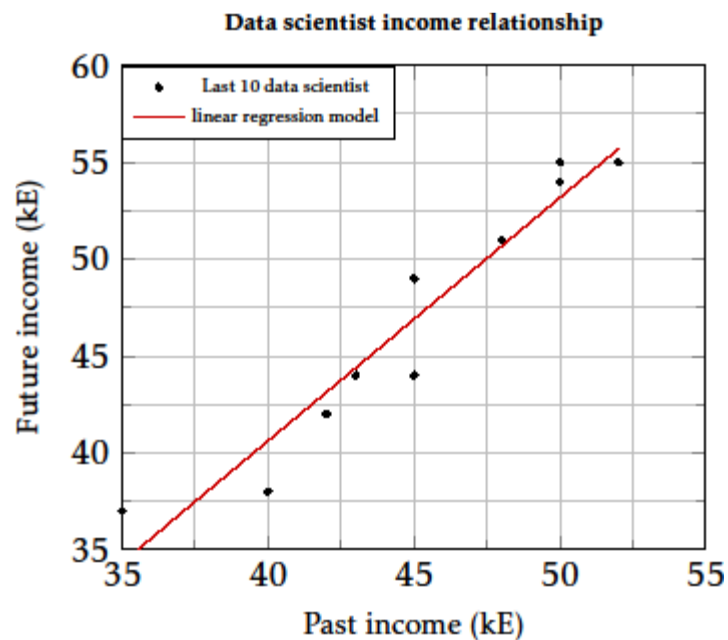
What you want to accomplish is to find whether there is a relationship between their past and their new income (most likely there is 😊). This you might do by using a **Machine Learning** technique. In this case it would be one of the simplest ones: a **linear regression**.

Let's say the data looks like this



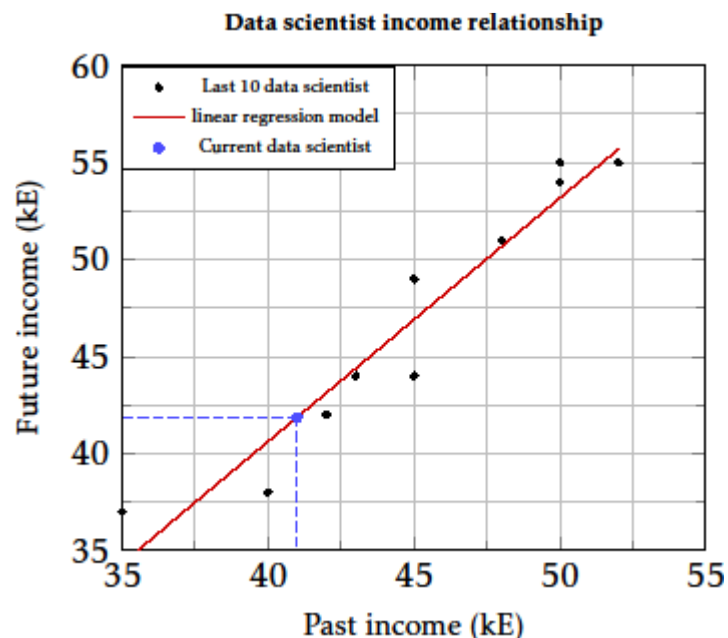
Where the horizontal axis gives you the past income of the last 10 data scientists that you got hired, and the vertical one the income that they now have. You might more or less visualize a line passing through these points. If you do, congratulations, you have just designed a machine learning algorithm!

Linear regression gives you the line that fits best your data. Setting the (simple in this case) math aside, here is what you find:



This red line is your **Machine Learning** model. Now you have a predictive algorithm. If someone gives you a past data scientist salary, you can try to predict his future one by looking at the corresponding value on the red line.

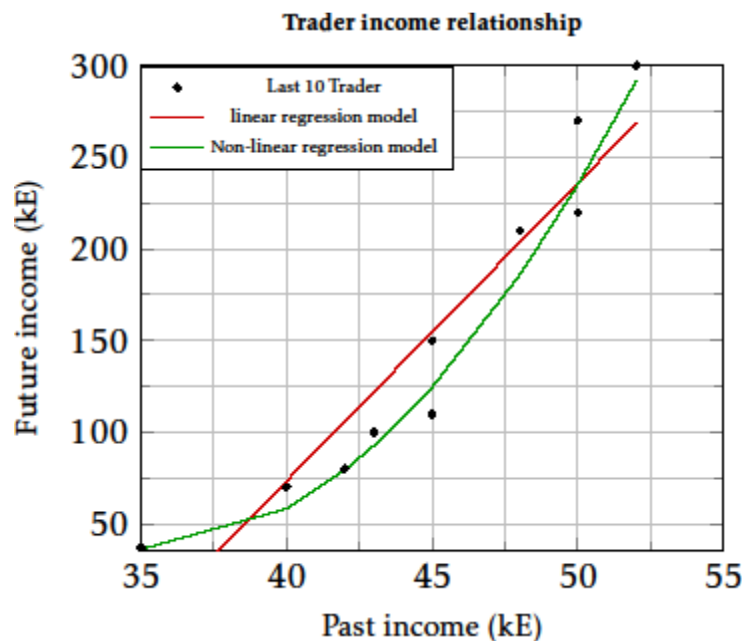
For instance, the data scientist that you didn't yet manage to get hired has a current income of 41kE, and is asking for a new income of 45kE. Your model predicts 41.9 kE, so most likely he is just asking too much.



Of course, in real life this model is way too simple. Future income also depends on the highest diploma obtained, number of previous years of experience... Thus the variables that could explain the future income are **multi-dimensional**.

In addition, we assumed the relation between past and future income to be linear. But it might well be that this relation is **nonlinear**: low income increases rapidly, while high income

increases slowly. In finance it might be the other way around ☺, as illustrated on the following figure



Here the linear model (in red) does a poorer job than the non-linear one (in green).

2) Deep Learning

If your problem at hand is **multi-dimensional**, and **nonlinear**, then **Deep Learning** is the way to go, as it is exactly what this **Machine Learning** technique is designed to do.

Deep Learning is based on an analogy with the human brain, where neurons communicate with each other thanks to axons. In **Deep Learning**, one creates an artificial neural network, where the explanatory variables (past income...) are the input neurons of this network and the output variables (future income) the output one. In between lies the **Deep Learning** magic: how you model the relation between the input and the output is as much a science as an art, since the most recent advances in the field are not theoretically understood.

Deep Learning can manage a humongous quantity of data, but there is a price to pay. In our example for instance, you would lose the explanatory power of the model: you would no longer be able to tell why it is that a low past income implies a not so high future income. The effect of all explanatory variable gets mixed together, and the web cannot (yet) be disentangled.

Nevertheless, for multi-dimensional problems, Deep Learning has produced impressive results. For instance, reading zip codes on mails can be a daunting task: one describes the zip code by an image with a numerous number of pixels, and one wants to know whether the number is a 0-9. Current state of the art Deep Learning techniques can accomplish this task better than human eyes, and several orders of magnitude faster!

Mediamobile is therefore using this powerful tool that is **Deep Learning** as its road traffic speed prediction algorithm.

3) Innovation at Mediamobile

The Mediamobile Innovation team is keeping up to date with state of the art machine learning techniques and applying them to pressing issues in road traffic.

- **Bayes Network** allows us to evaluate in real time the accident risk on roads;
- We use **Bayesian Inference** to aggregate in real time individual car speeds to an average speed on a given road;
- We implement **Deep Learning (Feedforward, Convolutional and Recurrent Neural Networks)** to predict future traffic
- We complete in real time missing road speed data thanks to **Non-Negative Matrix Factorization**

We from time to time also produce exploratory work on our road speed and density archives, for instance to see the effect on traffic jams of a car circulation restriction imposed by the government.

The innovation team has developed its expertise over the years thanks to a fruitful collaboration with professors/researchers in Statistics at the Institut Mathématique de Toulouse (IMT).

4) Mediamobile cares about spreading knowledge

We might be a private company, but we like to exchange with the Machine Learning community. We learned a great deal from it, and try to return the favor when we can. Thomas for instance recently published a lengthy note on the technical aspects of Deep Learning on the famous electronic preprint repository that is **arxiv** (<https://arxiv.org/abs/1709.01412>). All the material used to publish this note can be found on Github (https://github.com/tomepel/Technical_Book_DL). Hope it can help others!

5) Contact us

Would you want any additional information, don't hesitate to email Philippe Goudal, Thomas Epelbaum or Jessica Martin, who will be glad to answer you!