

# Swissquote Conference 2020 on Finance and Technology

**Antoine Savine and Brian Hüge (Superfly Analytics at Danske Bank)**

**Title: Differential Machine Learning**

**Abstract:** Brian Hüge and Antoine Savine of Superfly Analytics at Danske Bank present Differential machine learning (ML), an extension of supervised learning, where ML models are trained on examples of not only inputs and labels but also differentials of labels wrt inputs.

Differential ML is applicable in situations where high quality first order derivatives wrt training inputs are available. In the context of financial Derivatives and risk management, pathwise differentials are efficiently computed with automatic adjoint differentiation (AAD). Differential machine learning, combined with AAD, provides unreasonably effective pricing and risk approximations. We can produce fast pricing analytics in models too complex for closed form solutions, extract the risk factors of complex transactions and trading books, and effectively compute risk management metrics like reports across a large number of scenarios, backtesting and simulation of hedge strategies, or regulations like XVA, CCR, FRTB or SIMM-MVA.

The talk focuses on differential deep learning (DL), arguably the strongest application. Standard DL trains neural networks (NN) on punctual examples, whereas differential DL teaches them the shape of the target function, resulting in vastly improved performance, which we illustrate with a number of numerical examples, both idealized and real world. In the online appendices, we apply differential learning to other ML models, like classic regression or principal component analysis (PCA), with equally remarkable results.

Our GitHub repo <https://github.com/differential-machine-learning> contains a TensorFlow implementation, tested on Google Colab, along with examples from the talk and additional ones. We also posted appendices covering many practical implementation details not covered in the paper, mathematical proofs, application to ML models besides neural networks and extensions necessary for a reliable implementation in production.

*The talk concludes with a live demo of the implementation in Superfly, Danske Bank's proprietary risk management system.*