Msc. thesis proposal:

High Dimensional Numerical Integration Using Machine Learning Approaches And the Application to the Computing Characteristics Function in High Dimensional Models

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**Background**

The characteristics function of a real-valued variable is the Fourier transform of the probability density function. There is a unique relation between the characteristics function and the distribution function of that random variable. I.e., the characteristics function completely defines the probability distribution.

In practice, solving the characteristic function is not always straightforward, particularly in high dimensional models. For example, the loss distribution of a large portfolio consisting of risky positions is often modelled via a factor copula model, and the number of factors can be a large number up to hundreds. Solving the characteristics function of the loss distribution essentially boils down to the calculation of a high dimensional integration.

Recently there have been machine learning methods developed to efficiently compute the high dimensional integrations. However, the accuracy and speed of these methods remain to be tested in real-world applications.

The subject of our interest in this study is taking a machine learning approach to calculate the characteristic function of a high dimensional model. Though machine learning methods for high dimensional integral already exist, careful attention has to be paid when it comes to computing the characteristics function, because small errors in the Fourier domain (errors in the calculation of the characteristic function) can lead to large errors in the real/physical domain of the density function.

**Challenge**

The challenges are two folds:

1. Finding a machine learning method that is indeed efficient enough.
2. Ensuring the errors are within the tolerance range, particularly the errors in the domain of the probability distribution function.

**Contact**

If you are interested to enter the field of quantitative analysis, this is a very good starting point. Please feel free to contact me directly if you would like to learn more: [fang.fang@ffquant.nl](mailto:fang.fang@ffquant.nl) or [F.Fang@tudelft.nl](mailto:F.Fang@tudelft.nl).

**Reference**

1. Boram Yoon. A machine learning approach for efficient multi-dimensional integration. Sci Rep 11, 18965 (2021). <https://doi.org/10.1038/s41598-021-98392-z>
2. Christina Gao and Joshua Isaacson and Claudius Krause. i- flow: High-dimensional integration and sampling with normalizing flows. Machine Learning: Science and Technology, 1, (2020). <https://doi.org/10.1088/2632-2153/abab62>

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We provide quantitative consulting services to banks, brokers, insurance companies and other financial institutions. Our expertise include the development, validation and audit of regulatory and non-regulatory risk models and pricing models of financial instruments.

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