Machine Learning for Finance

Quant GANs: Deep Generation of Financial Time Series

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Quant GANs principle

- Approximating a realistic asset price simulator by using neural networks and adversarial training techniques.
- Two different NNs as opponents.
- Generator is responsible for the generation of stock price paths.
- Discriminator has to judge whether the generated paths are synthetic or from the same underlying distribution as the data.
- Pitfalls : limited convergence when optimizing both networks , extrapolation problems when using recurrent generation schemes.

Main thread

- Use a temporal convolutional networks (TCNs) as the generator architecture.
- Generator architecture : Stochastic Volatility Neural Networks (SVNNs), volatility and drift TCN and an innovation NN.
- Being able to model complicated or unknown dynamics.
- Outperform Garch models.

Preprocessing

- Historic data of SP 500 index from May 2009 to December 2018.
- Performance of a stock over a certain period is its relative log return : $r_t = \log\left(\frac{s_t}{s_{t-1}}\right)$ for all $t \in \{1, \ldots, T\}$.
- Normalize the data in order to obtain a series with zero mean and unit variance.

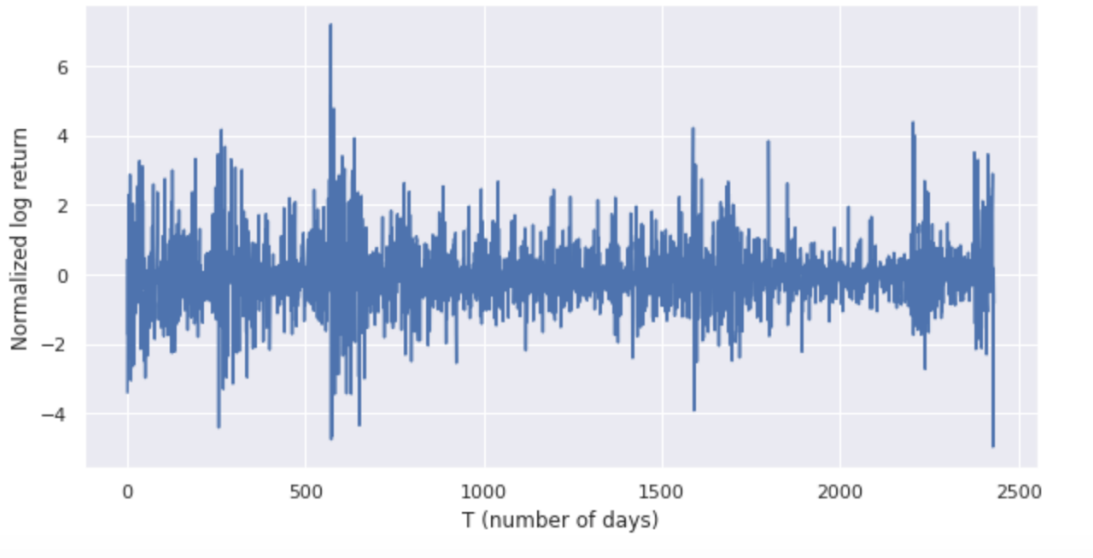

Figure – Log return normalized

Preprocessing (2)

- location-scale *Lambert* $W \times F_X$ to transformed log returns, and normalize it : $Y = r_t \times exp\left(\frac{\delta}{2} r_t^2\right) \sigma + \mu$.

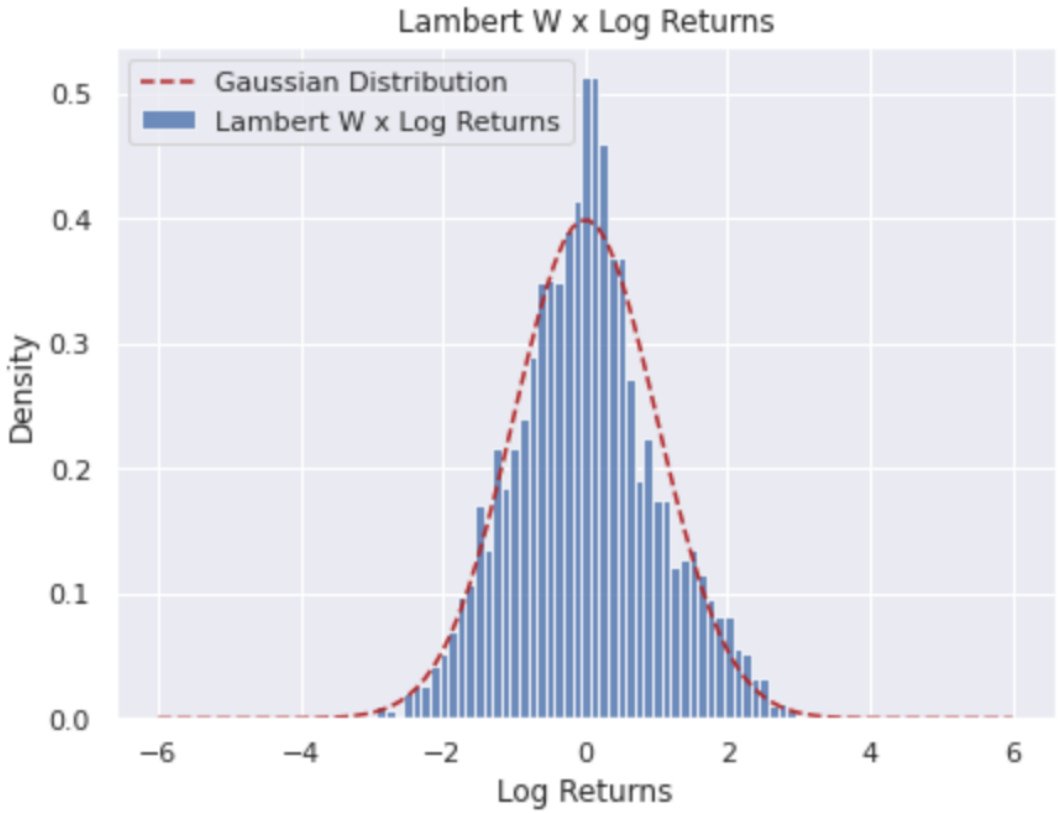

Figure – Lambert W x Log Returns

Models Parameters - Pure TCN

The first model we implemented is the pure TCN model with skip connections, and is constructed with this architecture :

- Generator has input dimension of 3, output dimension of 1 ; and Discriminator has input and output dimension of 1.
- Generator and Discriminator has seven temporal blocks, with hidden dimensions set to 80.
- Each temporal block has a kernel size of 2, except the first one which as a kernel size of 1.
- Dilatation of each temporal block is given in this table

Temporal Block	1	2	3	4	5	6	7
Dilatation	1	1	2	4	8	16	32

- The last layer is the convolution with output of dimension one, kernel size and dilatation are equal to one.

Models Parameters - C SVNN

The second model we implemented is the Constrained SVNN model with skip connections, and is constructed with this architecture :

- Generator has input dimension of 3, output dimension of 1 ; and Discriminator has input and output dimension of 1.
- Generator and Discriminator has seven temporal blocks, with hidden dimensions set to 50 for the Generator and 80 for the Discriminator.
- Each temporal block has a kernel size of 2, except the first one which as a kernel size of 1.
- Dilatation of each temporal block is given in this table

Temporal Block	1	2	3	4	5	6	7
Dilatation	1	1	2	4	8	16	32

- The last layer is the convolution with output of dimension one, kernel size and dilatation are equal to one.

Numerical results - Pure TCN

- In our implementation, numerical results are :

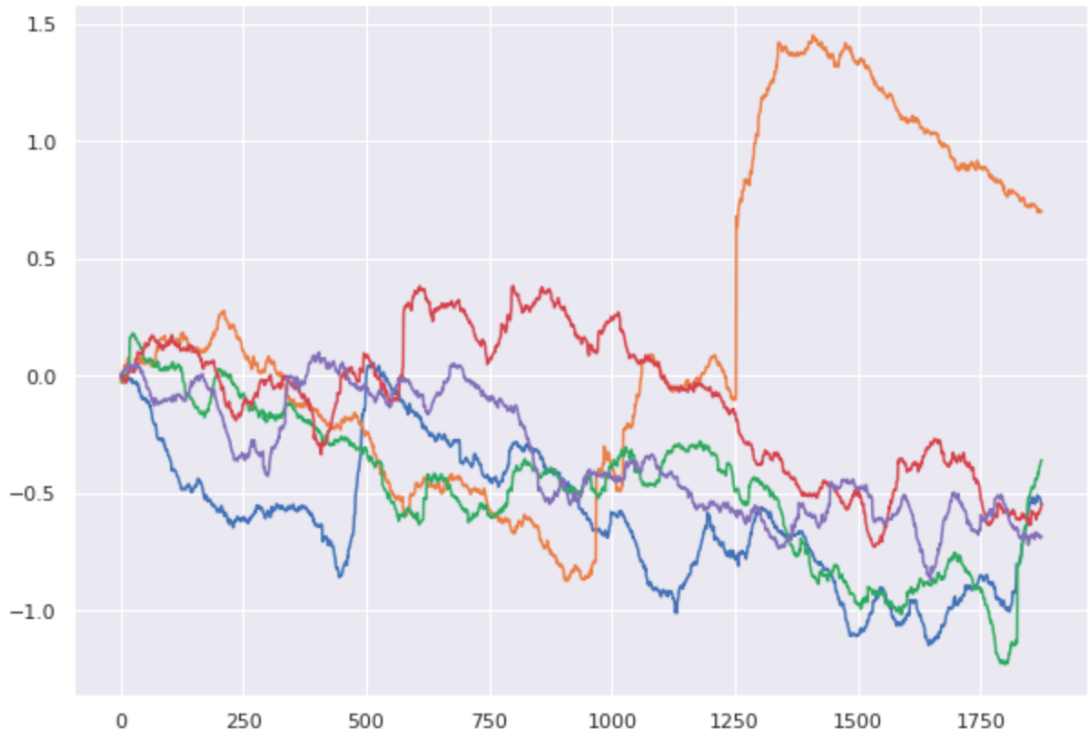

Figure – Pure TCN log path

Numerical results - Constrained SVNN

- In our implementation, numerical results are :

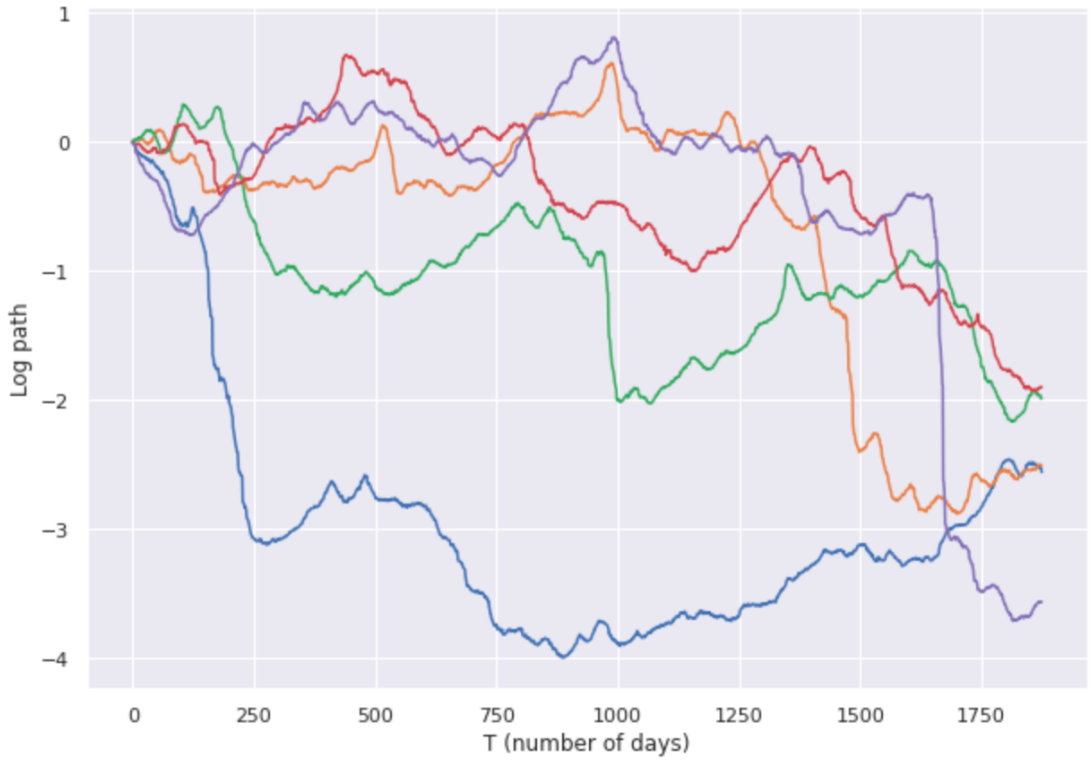

Figure – Constrained SVNN log path

Critical look at the results

- The generated time series are less convincing than the results in the paper.
- They are decreasing and not in the same magnitude than in the article.
- A plot of densities of the generated log returns would not match with the historical density.
- We did not use a regularisation algorithm as it is the case in the article, and we did not have enough power to train with much more epochs in a reasonable time.

Conclusion

- The authors did not provide the values of some important hyperparameters (number of epochs, size of the generator input noise, lenght of the tcn layers).
- Architecture for the innovation neural network is not mentionned.
- Refers to a GAN stability algorithm, but no explicit description of such method.