A Deep-Learning Estimator for the Hurst Exponent of Two-Dimensional Fractional Brownian Motion: Its Evolution and Applications

Prof. Yen-Ching Chang

Department of Medical Informatics, Chung Shan Medical University, Taiwan

The topic is about the evolution of an estimator from one-dimensional data (signals) to two-dimensional data (images), and then from traditional computation to deep-learning computation. For estimation, the input is the data about fractional Brownian motion (FBM), the output is the estimate of the Hurst exponent (the parameter to be estimated), and the tool or the function is the estimator. The history of the topic is also my research journey. The journey begins with the maximum likelihood estimator (MLE) for the Hurst exponent of one-dimensional FBM (1D FBM). For estimators, two important factors must be considered: accuracy (effectiveness) and speed (or efficiency). In general, the higher the accuracy, the slower the speed. Therefore, we are often faced with the dilemma between accuracy and speed. As we know, the MLE is optimal in accuracy, but it generally takes much time to estimate. The MLE is undoubtedly the best choice if time is not an issue. Otherwise, we need other speedy estimators with acceptable accuracy.

Following the logic, several approximate MLEs were developed one after another, and in the end, an efficient MLE was discovered. As the name implies, the efficient MLE has the accuracy of the MLE, but its speed is much quicker than the MLE. Extending the skill of how to efficiently implement MLE for the Hurst exponent of 1D FBM, an efficient MLE for the Hurst exponent of two-dimensional FBM (2D FBM) was further proposed. Even though the efficient MLE for 2D FBM has the optimal accuracy and its speed is the currently quickest among MLEs, its computational time is still considerably high. With the development of deep learning, deep-learning estimators (estimators through deep-learning models) for the Hurst exponent of 2D FBM were further proposed. Experimental results show that the trained deep-learning models for images of 2D FBM not only provoke smaller computational costs, but they also cause smaller mean-squared errors than the efficient MLE, except for size $32 \times 32 \times 1$. Finally, the potential applications in the future will be introduced. At present, these deep-learning estimators are indirectly through deep-learning models for classification. In the future, estimators directly through deep-learning models for regression will be developed.

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Experience:

Yen-Ching Chang was born in Changhua, Taiwan, ROC, in 1966. He received the B.S. degree in electrical engineering from National Taiwan Institute of Technology, Taipei, Taiwan, in 1991 and the M.S. and Ph. D. degrees in electrical engineering from National Tsing Hua University, Hsinchu, Taiwan, in 1993 and 2002. Since 2003, he has been with Department of Medical Informatics, Chung Shan Medical University, Taichung, Taiwan, where he is currently a professor. His research interests include statistical signal processing, image processing, soft computing, machine learning, and deep learning.