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# INVOLVING STUDENTS IN RESEARCH COLLABORATION WITH INDUSTRIAL GLOBAL LEADER

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Synergy between the academia and industry work has always been a driving factor for fast research development. This process is easier to be observed and executed in engineering fields; however, it is currently possible also for Mathematics. Data science, artificial intelligence, machine learning, deep learning are currently buzz words present all around the world. It is crucial to observe that Mathematics lays in the roots of each of those topics and the industrial partners are actively seeking for partners in academia.

This includes all the variety of verticals, e.g. medicine (advanced statistics for new drugs analyses, simulations of new drugs creation, etc.), computer science (algorithms, floating point arithmetic, architectures optimization), industry (process control optimization, on-the-fly monitoring algorithms) or traveling (various discrete programming logistics optimizations for best routes with lowest costs, minimal delays, and eventually highest gains.

Below is the case study that might be used as a guideline on how to involve gifted students within such a collaboration with success. The first step was to set-up a frame research agreement between the Faculty and a partner from industry. Such collaboration was established between AGH University of Science and Technology and NVIDIA Corporation, global leader in GPU accelerators, high performance computing, and artificial intelligence. It was broadly determined to seek for optimal algorithms for numerical problems, e.g. ordinary differential equations, stochastic differential equations, deep neural networks.

The next step was to align students' master theses with this research. The mutual benefits were:

– for students – working on interesting and perspective topics, that could increase their chances of getting employed by top companies;

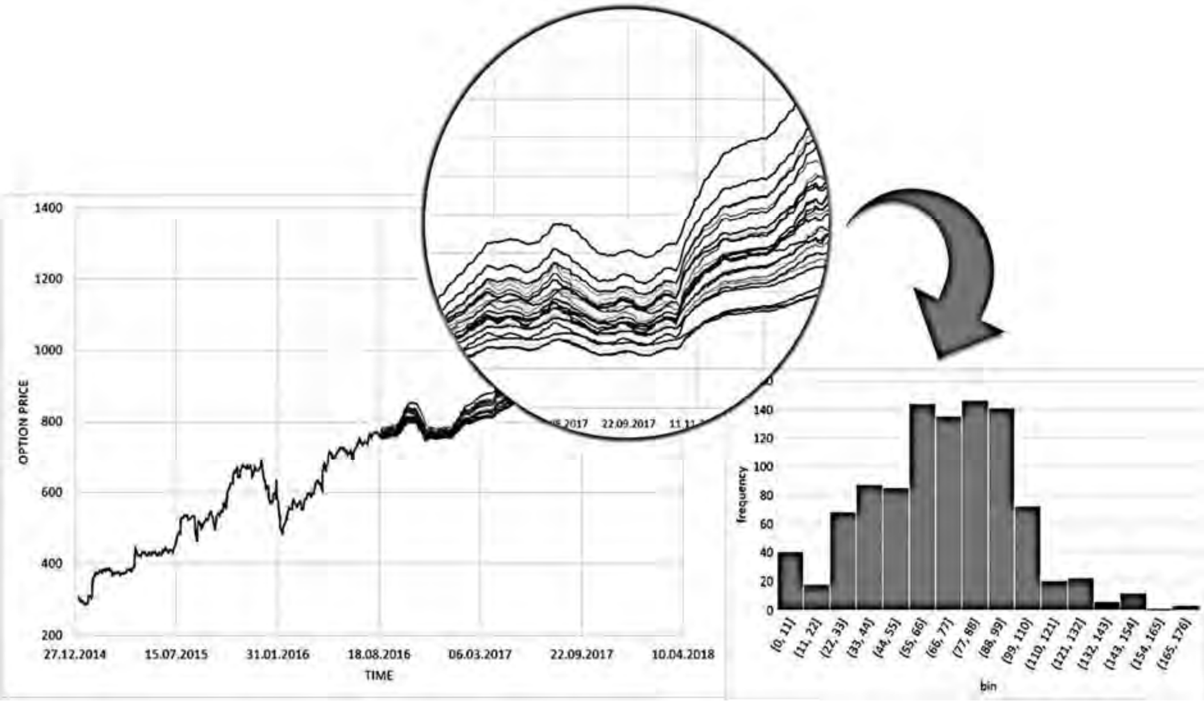
– for academia researchers – increasing bandwidth for running experiments, providing materials;

– for industrial partner – involving gifted students, potentially increasing chances of recruiting talents with previous expertise in the field especially interesting for them.

In the case the problem was formulated on how to create the hybrid model of financial option pricing. The model is a hybrid of both stochastic differential equations modeling and training complex deep learning models. During the initial studies a poster was created and submitted for a global conference – GPU

Technology Conference that is taking part in San Jose (California, USA). As the poster was accepted by the organizers, it will be presented during this event. Below is the brief of the poster.

The intuition is as follows: some derivatives, e.g. an Asian option, depend on the future trajectory of the real financial process (e.g. stock price for a chosen company). It is assumed that the financial process belongs to a class of stochastic processes that can be represented by a stochastic differential equation (SDE). Assuming that and having the historical values of the real financial process, one is able to estimate the coefficients of the SDE, which in turn allows to simulate the process' future values by application of some numerical scheme. Since the future values of the derivative are random, a single simulation would result in a different number at each repetition. Hence, the future values are approximated through generating many trajectories by some numerical scheme. Finally, based on the generated approximations, the derivative's (e. g. Asian option's) price can be estimated, as well as its empirical distribution.




Summarizing, the problem of option pricing can be divided into the following phases:

A. Modelling the underlying stochastic process (e.g. stock price), i. e. deriving a stochastic differential equation whose solution will be a good approximation of the real process.

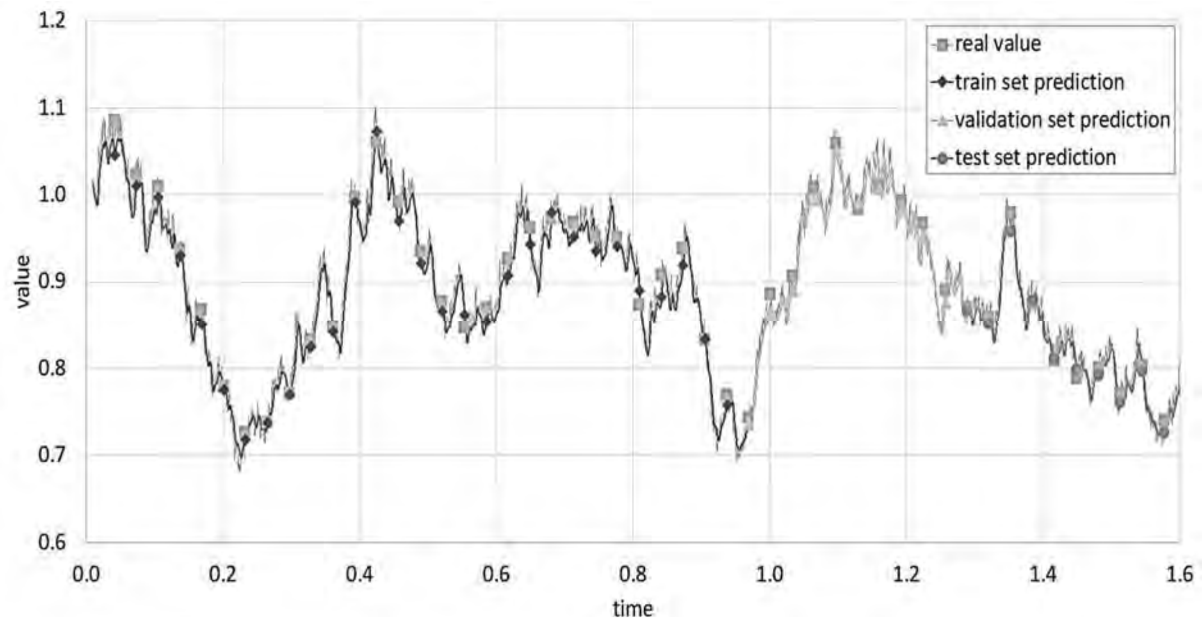
B. Estimating the parameters of the model.

C. Simulating multiple trajectories of the SDE's solution (this step includes choosing a proper numerical scheme for approximating SDE's solution).

D. Estimating the price of the derivative, together with its probability distribution.

For the phase A the most popular models would be Black Scholes, Heston, Merton or their variations with jumps or including stochastic volatility, cf. [1]. It turns out that the most computationally demanding are phases B, C, and D. Fortunately, each of them can be considerably accelerated by using GPUs. The phase D is commonly realized as the standard Monte Carlo simulation.

The most interesting was the application of Deep Neural networks for the problem (e.g. CNNs, RNNs, Sequence-to-sequence RNN, Attention-based RNN). The resulting predictions are promising and are currently work in progress. Below is a figure with current results.




Summing up, including gifted students into international research collaboration with industrial partner is an excellent way to motivate them and to advertise the possibilities for potential students.

## СПИСОК ИСПОЛЬЗОВАННОЙ ЛИТЕРАТУРЫ


1. **Monique Jeanblanc** Mathematical Methods for Financial Markets / Monique Jeanblanc, Marc Yor, Marc Chesney // Springer. – 2009.