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Short Communication

Parameters in Quantum Systems Lester Ingber

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Abstract

Previous papers have developed a statistical mechanics of neocortical interactions (SMNI) fit to short-term memory and EEG data. In both systems, Adaptive Simulated Annealing (ASA) was used for all fits to data, and path-integral codes were used for quantum systems. For both systems, a quantum systems code was developed, yielding the wave-function (the absolute square of which is a probability).

The mathematical-physics and computer parts of the study are successful:

For the Neuroscience project, using the author's closed-form derivation for a closed-form expression, three cases with Subjects after 1,000,000 visits to the cost function gave: Subject-07 = 0.04, Subject-08 = 0.55, and Subject-09 = 1.00. All other 9 Subjects gave 0.

Similarly, for the Finance project, the mathematical-physics and computer parts of the study are successful: Using the author's numerical code for any-dimensional path-integral, a 1-dimensional path-integral is required for fitting the Implied Volatility.

Keywords: Path Integral; Quantum Systems; Supercomputer

Introduction

Here, "Classical" refers to Classical (non-quantum) physics, and "Quantum" in capital letters refers to quantum systems; the reader is asked to look at the context at capital letters the for the first word in any sentence. The same math-physics methodology is used for both systems, Classical ASA for optimization and path-integrals for Quantum systems.

Both systems use path-integrals -- the Neuroscience code uses a closed-form derivation developed by the author, and the Finance code uses a numerical code developed by the author.

Neuroscience

SMNI has been published since 1981 [1,2]. This evolving model including ionic scales have been published since 2012 [3]. Quantum physics calculations also support these extended SMNI models. Papers that have developed quantum systems using Classical computers appeared circa 2013 [4]. A paper that details the math-physics to date used in the projects is "Quantum Calcium-Ion Interactions with EEG" [5].

In the Neuroscience project, since a closed-form expression was found which made computation faster, this expression was modeled another derivation (without the influence of the Vector Potential field A) [6].

Finance

SMFM has been published since 1984 [7]. Papers that have developed quantum systems using Classical computers appeared circa 2018 [8]. A paper that details the mathematical-physics used in this project is "Developing Bid-Ask Probabilities for High-Frequency Trading" [9].

In the Finance project, the importance of American Options required a numerical code anyway, and so this requires such code.

Methodology

Neuroscience

The methodology used in the Neuroscience project starts with modeling pyramidal neurons in the brain, using a wire as a model for this class of neurons, the largest contributor to firings. The sensitivity to E and B, being derivatives of the A fields diminishes fast with respect to distance from this wire, but the field A itself is logarithmic with respect to distance and does not suffer from this constraint. This leads to a wave function, dependent explicitly on A and not on its derivatives.

Finance

The methodology used in the Finance project starts with an understanding of how American Options are calculated. Probabilities associated with multiple nodes are first calculated going forward in time. Then, each node going back in time is tested to see if early

exercise is possible for a given Strike; if it is possible to early exercise the Strike, then this is considered to be done, and the price is calculated at this node.

Main results

This Section gives the main results relevant to this paper.

Neuroscience

The results are clear: there are quantum effects, but not always as strong by simply taking 1/2 of the quantum contribution: Using the author's closed-form derivation for a closed-form expression, three cases with Subjects after 1,000,000 visits to the cost function gave: Subject-07 = 0.04, Subject-08 = 0.55, and Subject-09 = 1.00. All other 9 Subjects gave 0.

It is noted that a separate paper has been published giving the key equations required to insert SMNI info an AI system [10].

Finance

All Strikes are numerically calculated, as explained above, and given in the Results below.

Results

The results are successful for both systems. They both have Real and Imaginary parts, but only the Real parts are essential here since that is what currently are measured.

A previous paper has shown how shocks (e.g., dividends) are included in these calculations [11].

Neuroscience

The mathematical-physics and computer parts of the study are successful, in that three cases with Subjects (blind to this author) after 1,000,000 visits to the cost function gave: Subject-07 = 0.04, Subject-08 = 0.55, and Subject-09 = 1.00. All other 9 Subjects gave 0.

Finance

The simplest approach to ImpVol calculations is to use ASA to search a large domain of values to find a minimum, to reproduce the volatility used to generate a set of Strikes. When this is done, ASA returns the volatility 0.126 which was used to generate the set of strikes using qPATHINT.

When two executables are used (one for qPATHINT and for ASA), the results are the same: ASA returns -0.126 as the minimum value when the cost function is not permitted to go below 0 after 591 visits to the cost function (setting the total visits to 1000 or to 10000 gives the same result).

All Strikes show the same proper behavior.

Conclusion

This latest round of optimizations, for both the Neuroscience and Finance projects, show that there are indeed quantum effects.

In the Neuroscience project, perhaps not a surprise, the degree of these effects varies considerably among Subjects.

For the Finance project, it was expected that ImpVol could be calculated. However, the first method used, just inserting the volatility, was unexpected, but this also worked very well. The second method, recalculating the full path-integral for each cost function, provided a good test of this method.

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Neuroscience

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