Researchers explore quantum computing's ability to speed solutions for financial sector

March 12 2024, by Karen B. Roberts

Credit: Jeffrey C. Chase/University of Delaware

Over the next decade, quantum computers are expected to have a transformative impact on numerous industry sectors, as they surpass the computational capabilities of classical computers. In finance, for example, quantum computing will one day be used to speed banking, make financial predictions and analyze financial patterns and risks.

The technology, however, is still in its infancy.

The University of Delaware's Ilya Safro, associate professor and associate chair for graduate studies and research in the Department of Computer and Information Sciences, is part of a team of researchers from industry, academia and the U.S. Department of Energy's Argonne National Laboratory that recently published a primer on quantum computing and finance.

The paper, published in *Nature Reviews Physics*, summarizes the current state of the art in quantum computing for financial applications and outlines advantages and limitations over classical computing techniques used by the financial industry. It also sheds light on some of the challenges that still need to be addressed for quantum computing to be used in this way.

It's an important topic across the world and at UD, which is among the first institutions in the United States to offer an interdisciplinary graduate degree program in quantum science and engineering.

The work, facilitated by the Chicago Quantum Exchange (CQE) and led by a team that includes UD, Argonne, JPMorgan Chase and University of Chicago scientists, lays groundwork for future applications—and highlights the need for cross-sector collaboration. Other partners include Fujitsu Research of America, Inc., and Menten AI.

The hope, Safro said, is to bring the financial world to what is called "practical quantum advantage," where processes are faster, more accurate and more energy efficient.

"Finance is an area where even a small improvement will be felt—literally—in dollars," said Safro. "Even a tiny improvement at the level of economy will be very significant. For example, it may amplify efficiencies across entire industries, leading to substantial cost reductions, enhanced productivity or more sustainable practices."

This is one reason finance is considered a major beneficiary of quantum computing.

Written for researchers who aren't necessarily quantum computing experts, the team views the primer as a one-stop resource on the use of quantum computers to accelerate solutions for the finance sector. The paper discusses challenges in three categories at the intersection of finance and computing: optimization, machine learning and stochastic modeling.

"We got together as a group of researchers from different institutions to better understand the state of the art of quantum computing for financial applications," said Marco Pistoia, head of Global Technology Applied Research at JPMorgan Chase. "We wanted this to be appreciated by a larger audience. Our paper can be the starting point for researchers to better understand the landscape and then dive deeper in the areas that they're interested in."

Quantum computing harnesses features of physics at the level of the atom to perform computations at speeds that leave traditional computing in the dust. In some cases, a quantum computer will be able to calculate in a few minutes what it would take a supercomputer 10,000 years to run.

"The upside of quantum computing is absolutely humongous," said Argonne scientist Yuri Alexeev, one of the report's co-authors. "We're talking about a potential speedup of millions of times for solving certain problems."

It is precisely the advantage of supersonic speed that finance experts are interested in.

"In the financial world, time and accuracy are of the essence," Alexeev

said. "Getting solutions quickly can have huge benefits."

This could apply to everything from improving portfolio management to optimizing investment strategies to advancing the speedy detection of credit card fraud, to name just a few examples.

"All these problems sound very general, but in fact, they are mathematical problems. Moreover, many of them are mathematical optimization problems," said Safro, whose expertise is in algorithms and models for quantum computing, machine learning and artificial intelligence systems, with a focus on natural language processing.

The three categories of challenges the paper discusses—optimization, machine learning and stochastic modeling—are at the intersection of finance and computing.

Optimization refers to methods for rapidly obtaining the best solution to a problem. For example, financial companies could use quantum computers to rapidly select assets that would provide the maximum return on a customer's investment with minimal risk.

The second category, machine learning, is already a part of many financial institutions' toolkits. In machine learning, computers draw on massive data sets to make predictions about various behaviors, such as patterns in the stock market. Combining quantum algorithms with machine learning can massively speed up those predictions.

The third category, stochastic modeling, is used across the sciences to predict the spread of disease, the evolution of a chemical reaction, or weather patterns. The mathematical technique models complex processes by making random changes to a variable and observing how the process responds to the changes.

The method is used in finance, for instance, to describe the evolution of stock prices and interest rates. With the power of quantum computing behind it, stochastic modeling can provide faster and more accurate predictions about the market.

According to Safro, one of the things that makes the field and ongoing research in this area exciting is the unknown.

"Currently, there is no one specific quantum technology that we know for sure will take over the market," he said.

This means that multiple quantum technologies and vendors must compete to scale up quantum hardware, making it more powerful, reliable and accessible for broad use in scientific research to practical applications for a variety of industries.

"Once researchers demonstrate practical scalability of quantum computing devices in one of these technologies, we will have an exact roadmap of how we build bigger and bigger quantum computers to tackle very large, real-world problems and how to hybridize them with classical supercomputers," Safro continued.

"With this literal breakthrough, I think the number of available jobs in quantum computing will explode, similar to what we have seen today with artificial intelligence."

More information: Dylan Herman et al, Quantum computing for finance, *Nature Reviews Physics* (2023). DOI: 10.1038/s42254-023-00603-1