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Leveraging Quantum Technologies to Address the Next Pandemic

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Introduction

The coronavirus outbreak has had a devastating effect on society and further highlights deficiencies in our ability to mitigate our response to the infection.

New technologies, such as quantum computing offer potential solutions for modeling ways to combat novel threats like the coronavirus. On January 20, 2020, the Center for Disease Control (CDC) developed tests to detect the country's first coronavirus cases.[1] The CDC began its tests by using three small genetic sequences to match up with portions of the virus's genome that were taken from swabs containing the virus. However, findings by the Food and Drug Administration (FDA) showed that these tests gave inconclusive results.[2] By mid-February, only 100 samples per day were being tested, resulting in a dramatic setback in tracking the virus and understanding it. Nonetheless, there remains a need to treat individuals affected by the COVID-19 virus and vaccinate against future outbreaks while simultaneously developing models to simulate community spread and use those models to determine policy to best provide efficient relief.

I. Drug Manufacturing

The manufacturing of pharmaceuticals for consumer consumption is an arduous and expensive process often resulting in delays in production and substantial costs that are shifted to the targeted consumer. "Today, pharmaceutical companies take up to 10+ years and often billions of dollars to discover a new drug and bring it to market."[3] One method of developing pharmaceuticals relies on a brute force method that takes collections of compounds and determines whether any of those molecules are effective in treatment, but such processes are time consuming. Alternatively, understanding how the virus causes the infection

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[1] Michael D. Shear et. al., *The Lost Month: How a Failure to Test Blinded the U.S. to Covid-19,* New York Times, (Mar. 28, 2020), https://www.nytimes.com/2020/03/28/us/testing-coronavirus-pandemic.html (last visited Apr. 3, 2020).

[2] *Id.*

[3] *Biogen, 1Qbit and Accenture: Pioneering Quantum Computing in R&D*, https://www.accenture.com/us-en/success-biogen-quantum-computing-advance-drug-discovery (last visited Apr. 3, 2020).

can lead to specifically targeted treatments and vaccines, but requires a deeper understanding of the biology of the virus and genetic differences among humans. Currently, there are modeling programs that allow biologists to use bioinformatics to model three-dimensional structures and predict interactions between the virus and human cells. However, these models rely on classical computers and are thereby limited to a certain number of molecular structures and interactions that can be analyzed. Quantum computing, through inherent features of the technology, would allow pharmaceuticals and material science companies to more quickly model and analyze complex interactions between molecules, improving overall drug discovery processes by cutting costs and reducing time to market.

Quantum computing provides a means to solving difficult problems through quantum-enabled optimization, using sampling and machine learning algorithms.[4] The critical benefit to quantum computing lies in its ability to match and predict the positive effects of potential therapeutic approaches while reducing the negative side effects.[5] The inherent qualities of quantum computing allow molecular analyses that provide more contextual information about potential therapeutic molecules and modeling of those molecules in the treatment of disease.[6] This new type of modeling offers a significant improvement over the current pharmaceutical industry's drug discovery process and could expedite drug delivery.[7] In fact, quantum computing is already being used by D-Wave Systems to provide free access to its Leap Hybrid Quantum Cloud service to anyone who is working on responses to the coronavirus outbreak.[8] D-Wave uses a process known as quantum annealing, which simulates quantum phenomena and optimizes network systems.[9] "The company's hybrid quantum-classic cloud service could conceivably help researchers simulate molecular interactions between coronavirus and its target cells, or simulate the spread of the COVID-19 disease in complex settings."[10]

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[4] *Id.*

[5] *Id.*

[6] *Id.*

[7] *Id.*

[8] Alan Boyle, *D-Wave Systems open free access to quantum computing for coronavirus researchers*, GEEKWIRE (Mar. 31, 2020), https://www.geekwire.com/2020/d-wave-opens-free-access-hybrid-quantum-computing-coronavirus-researchers/ (last visited Apr. 3, 2020).

[9] *Id.*

[10] *Id.*

Quantum computing has already been considered for cancer treatment.[11] Due to the quantum computer's ability to deal with vast amounts of data and variables, radiation plans can be developed that target cancer cells while minimizing the risk of damaging healthy ones.[12] Moreover, quantum MRI machines can be used to generate precise imaging down to the individual molecule.[13]

The value of quantum computing to the medical field lies in the ability to store vast amounts of data from numerous sources and compile that data to recommend a specific medical therapeutics. Particularly, in regard to the coronavirus outbreak, new medications or early detection systems could be vastly improved through the utilization of quantum systems.

II. Simulating Outbreaks to Find Deficiencies in Our Supply Chain

Quantum computing may also provide insight on simulating the spread of various diseases in complex settings by taking into account a vast number of variables. Additionally, it could be used to simulate outbreaks and to find deficiencies in our supply chain and lead to helping planners optimize supply chains and hospital logistics.[14]

The recent outbreak of the coronavirus has caused a major disruption to many global supply chains. This disruption was further exacerbated by the simultaneous disturbance in demand that stem from supply shortages from China and demand disruptions in Italy.[15] The central question concerning supply chains is how long will a supply chain be able to endure disruption and how long will it take to recover after an pandemic outbreak.[16] Moreover, preparing contingency pandemic plans and tailoring operation policies prior to the pandemic are often the most efficient means of combating disruptions, yet it often remains elusive as to which supply chain policies are the most efficient to handle the disruptions with different levels of severity of the pandemic.[17]

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[11] Dmitry Solenov et. al., *The Potential of Quantum Computing and Machine Learning to Advance Clinical Research and Change the Practice of Medicine*, Mo Med. 2018; 115(5); 463-467.

[12] *Id.*

[13] *Id.*

[14] Boyle, *supra* note 8.

[15] Dmitry Ivanov, *Predicting the impacts of epidemic outbreaks on global supply chains: A simulation-based analysis on the coronavirus outbreak (COVID-19/SARS-CoV-2) case*, Transportation Research Part E: Logistics and Transportation Review, Vol. 136, April 2020, 101922, https://www.sciencedirect.com/science/article/pii/S1366554520304300?dgcid=author (last visited Apr. 3, 2020).

[16] *Id.*

[17] *Id.*

Simulations of an outbreak's impact on global supply chains provides a means of determining efficiency and crafting policies and contingency plans to combat disruption.

Simulation-based supply chain risk modeling allows for the prediction of supply chain behaviors over time, but current models need to be computed under conditions of time-dependent changes.[18] These models typically take into account logical and randomness constraints, such as "randomness in disruptions, inventory, production, sourcing, and shipment control policies, and gradual capacity degradation and recovery." [19] In addition to the supply chain considerations, there is also the variability presented by different populations and countries that are affected. The benefits of simulating outbreaks optimize situational changes in response to potential variables that may introduce risk to the supply chain.

Simulations on classical computers are limited. Quantum computers are able to scale disruption risk as the pandemic outbreak disperses over many geographic regions and supply chains. Quantum computing can analyze vast amounts of data, potential variables that could impact the efficiency of contingent supply chain policies. A system that could leverage numerous variables in an evolving circumstance could lead to a more efficient and successful outcome.

Conclusion

The advantages of quantum technologies are enormous. Quantum computing has the ability to quickly analyze biomolecules, drugs, and optimize potential therapeutic treatments to disease; decreasing production time for drug delivery. In addition to drug design and manufacturing, quantum computing has value in being able to better predict the trajectory of disease within a population and to optimize logistics of supply chain management during an outbreak.

Edited by Ben Davisson

[18] *Id.*

[19] *Id.*