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Quantum Leap in AI for Science

Highlights from a Roundtable hosted by the Advanced Technology Academic Research Center (ATARC) in partnership with Microsoft, October 2024

During a recent roundtable hosted by the Advanced Technology Academic Research Center (ATARC), Federal experts discussed the progress being made with AI and quantum technologies. Scientists have been developing quantum computing technology over the span of two decades, and are beginning to use quantum applications in real-world scenarios.

Quantum Computing: Potential and Challenges

> **“The good that quantum can bring from a material science perspective is overwhelming.”**

The potential for quantum to solve complex real-world problems is profound. Quantum technology is capable of processing vast amounts of data with incredible precision, enabling new discoveries in science that are not achievable with classical computing capabilities.

Scientists are now able to use quantum machines with AI and high performance computing (HPC) to solve complex chemistry problems and identify insights within weeks – a process which normally takes a decade. While quantum has the potential to solve complex problems, panelists note that certain problems will still be better solved by HPC.

Panelists say the anticipated quantum leap in science is possible due in part to the exponential growth and availability of data, and advancements in AI technology. The combination of these technologies will inevitably fuel innovation and lead to profound scientific breakthroughs.

While quantum presents infinite potential, it also introduces a new set of complex challenges for agencies to navigate and solve. Most agencies on the panel do not have the resources to devote to quantum computing; rather the current focus is on AI and immediate threats to cybersecurity.

Other agencies have considered specific quantum applications to improve decision-making and warfighting capabilities. By leveraging AI and quantum computing, agencies will be able to provide timely, accurate information to warfighters, enhance decision-making, and deny adversaries the same capabilities. Agencies are considering the requirements for small, portable quantum devices that require immense amounts of energy to power in challenging environments.

> **"Why did generative AI explode? Because of the availability of a lot of data...the availability of improved algorithms and improved compute power.”**

Panelists discussed the inability of existing architecture to manage the exponential increase in data created by generative AI. Even now, some agencies are not able to access or use the vast amount of data stored in data lakes. Panelists view quantum computing as the solution, but note that many questions still exist. Chief among them is how to realistically deploy quantum in classical environments. Panelists shared that the private sector is currently developing an interface between quantum and classical computing, which should be available soon.

Panelists also emphasized the need to protect critical infrastructure from quantum threats. For many the focus is on raising awareness of quantum capabilities, implementing standards, assessing risks to data, and testing algorithms to evaluate security of systems. Other panelists underscored the importance of migrating to more quantum resistant capabilities, such as modernizing programming languages to more secure versions. Agencies should also focus on collaborating with industry to address potential quantum security challenges.

The AI and Quantum Combination

> **“The [AI and quantum] combination is extremely powerful. Problems that would have cost too much or taken too long can now be solved with a fraction of the cost with solutions that would otherwise not be possible.”**

Panelists highlighted the synergistic relationship between AI and quantum computing. One panelist shared that data from a quantum machine has been used to successfully enhance the accuracy of AI algorithms, creating a feedback loop between classical AI and quantum.

However, panelists expressed uncertainty about how to test and validate the outputs of quantum computers, especially when the underlying processes are not fully understood. Some panelists raised concerns about user acceptance of unintuitive solutions, even if they are the most accurate. These challenges highlight the need for further research and development to establish trust and understanding in quantum computing outputs.

Creating Policies for AI

The need to share data to promote open science is critical to the success of future quantum deployment. However, panelists identified several challenges, including a lack of infrastructure for making data available and the need for more collaboration between public and private sectors.

Panelists note the value in leveraging industry expertise to create solutions that benefit the economy and society as a whole, but also acknowledge the far-reaching implications of these technologies. Collaboration is crucial to ensure responsible and ethical development and use of quantum and AI.

Final Thoughts

Panelists emphasized the need for a strategic approach to funding that fosters collaboration between labs and industry partners. They noted that a clear strategy for quantum and AI funding is crucial to avoid spreading resources too thin across multiple projects, potentially hindering significant advancements.

In addition, panelists stressed the importance of securing adequate government funding for these initiatives. This requires a well-defined strategy that clearly articulates the benefits and potential impact of quantum and AI technologies to Congress and the public. The rapid pace of AI advancements and the complexity of these issues necessitate a thoughtful and comprehensive funding approach to maintain national security and global leadership.

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