Tutorial on the use of Artificial Intelligence and Machine Learning in Quantum Computing

Speakers: Elizabeth Behrman and James Steck

According to Time Magazine, "Quantum computing represents the marriage of two of the great scientific undertakings of the 20th century, quantum physics and digital computing"[1] Quantum computing takes advantage of the rather odd and counter-intuitive rules of quantum mechanics like: superposition (a quantum system can be in more than one state or even one place at the same time), entanglement (instantaneous interaction at a distance) and quantum tunneling (a quantum system can switch states without surmounting an energy barrier between). Using these, a quantum computer can be built from very small, atomic sized, devices that can solve classical computing "hard problems", and even quantum problems that are classically impossible to formulate and solve. The down side is: 1) quantum computers can be very difficult to build, and 2) they are difficult or impossible to program.

Recent advances have dramatically addressed the first issue. D-wave Systems Inc. has developed commercially available quantum computing hardware that implements 512 super-conducting quantum interference (SQuID) devices as quantum bits (qubits). (The prior record was 4, then 20, ten years later.) A NASA Google partnership has purchased and installed a 512-qubit D-Wave Two™ device at Ames and has established the Quantum Artificial Intelligence Laboratory (QuAIL) at its NASA Advanced Supercomputing (NAS) facility.

In this Tutorial, we will give an introduction to quantum mechanics, then to the emerging field of quantum computing, then show how the use of AI and machine learning in quantum computing can be a powerful way of addressing the second issue.

The Tutorial is intended for the general AI community, and no prior knowledge or background in quantum mechanics will be assumed.

Speakers:

Elizabeth Behrman, Department of Mathematics, Statistics, and Physics, Wichita State University, Wichita, KS 67260; (316) 978-3953; elizabeth.behrman@wichita.edu

Behrman is professor of mathematics and physics at Wichita State. She has been working, with J.E. Steck, on quantum learning systems since the early 1990s. In 2002 they organized a workshop in quantum neural computing at the Neural Information Processing Systems conference (NIPS 2002), (http://www-2.cs.cmu.edu/Groups/NIPS/), and they have

[1] Time Magazine cover article, February 17, 2014, pp. 26-33.

together published seven journal papers, two book chapters, and eleven conference papers on the subject. In addition to quantum neural networks, she has published in many fields including inorganic spheroid molecules, high Tc superconductors, reaction pathways, and Feynman path integrals.

James Steck, Department of Aerospace Engineering, Wichita State University, Wichita, KS 67260; (316)-978-6396; james.steck@wichita.edu

Steck is a professor of aerospace engineering at Wichita State. In addition to applying learning and AI to quantum computing with Behrman, as described above, He has been adapting artificial intelligence and artificial neural network methods for aerospace systems since 1990. He has also done research in building optical neural networks, neural model reference adaptive flight control, and using neural networks for signal processing for aircraft and wind turbine structural health monitoring.