ZERNIKE INSTITUTE COLLOQUIUM

Thursday, November 2nd, 2017

16:00h, Lecture Hall: 5111.0080

Coffee and cakes from 15:30h

NEUROMORPHIC COMPUTING

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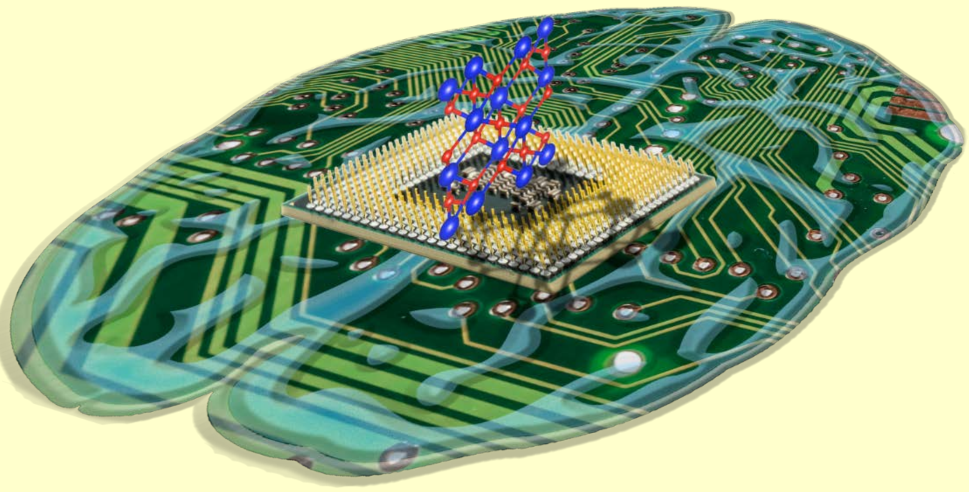
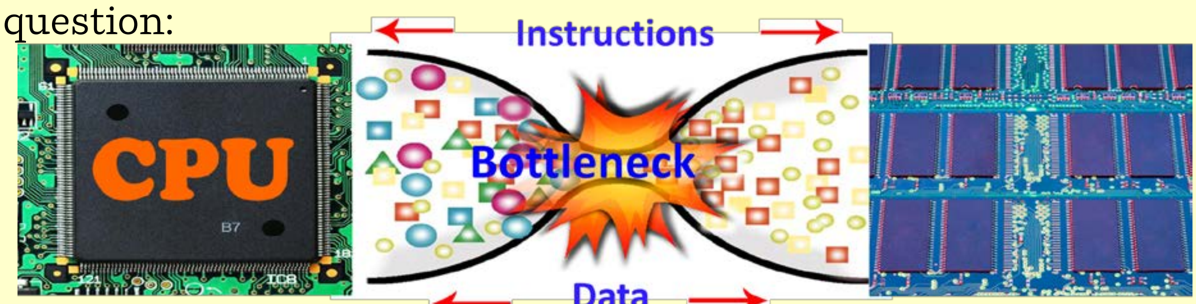


Data acquisition (sensors) and manipulation (memory, computation, communications, data mining) in its many forms drives and fuels our civilization. Biology has evolved complex intelligent systems that can acquire and manipulate data in a very efficient and comprehensive fashion. On the other hand, scientific and technological developments have led to the invention of highly sophisticated data acquisition and manipulation machines, which have been continuously improving over the last 50 years. Since biological systems can, in many cases, outperform artificial systems a natural question arises. Can biology provide, some high level, guiding principles useful for the development of revolutionary, new concepts for the development of artificial, intelligent systems ? An attempt to answer this question is the so-called "Biomorphic Science", which when applied to computation is denoted as "Neuromorphic Computation".

Modern computation is based on the Turing-von Neumann (TvN) architecture. Revolutionary developments in the past decades in hardware (principally CMOS technology) and software (such as machine-learning), has fueled the ever-increasing capabilities of modern computational machines. It is however agreed that the enhanced computational capabilities will soon (within the next 5-10 years) slow down considerably due to a variety of issues, which are connected probably to the foundation of the TvN type computing. On the other hand, nature has evolved a computational machine (the "brain") which has substantial advantages over conventional silicon based computers.

With extensive input from the community, the US Department of Energy convened a group of experts, which developed a report [1] to answer the following basic question:

"Can brain-like ("neuromorphic") computing devices based on new material concepts and systems be developed to dramatically out-perform conventional CMOS based technology?"



The importance of these types of questions is such that they have garnered the attention of the highest political and economic spheres. As an example recently the US White House announced the Nanotechnology-Inspired Grand Challenge for Future Technology [2]: "Create a new type of computer that can proactively interpret and learn from data, solve unfamiliar problems using what it has learned, and operate with the energy efficiency of the human brain".

In this talk, I will compare the performance and properties of conventional TvN computers and biological computational machines, and will describe at very high-level different approaches proposed to answer the above-mentioned challenge. It is particularly exciting that condensed matter/materials physics will clearly have an important role to play in this area.

I thank the Department of Energy (DOE), Basic Energy Sciences for the opportunity to co-chair a roundtable discussion resulting in the report, "Neuromorphic Computing: From Materials to Systems Architecture" and the US Department of Defense for a Vannevar Bush Fellowship.

[1] http://science.energy.gov/~/media/bes/pdf/reports/2016/NCFMtSA_rpt.pdf
[2] https://www.whitehouse.gov/blog/2015/10/15/nanotechnology-inspired-grand-challenge-future-computing

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