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Hyperdimensional Computing with Applications

ABSTRACT: In today's world technological advances are continually creating more data than what we can cope with. Much of data processing will need to run at least partly on devices at the edge of the internet, such as sensors and smart phones. However, running existing machine learning on such systems would drain their batteries and be too slow. Hyperdimensional (HD) computing is a class of learning algorithms that is motivated by the observation that the human brain operates on a lot of simple data in parallel. It has been proposed as a lightweight alternative to state of the art machine learning. HD computing uses high dimensional random vectors (e.g. ~10,000 bits) to represent data, making the model robust to noise and HW faults. It uses search, along with three base operations: permutation, addition (or bundling/consensus sum) and multiplication (circular convolution / XOR). Addition allows us to represent sets, multiplication expresses conjunctive variable binding, and permutation enables encoding of causation and time series. Hypervectors are compositional - they enable computation in superposition, unlike standard neural representations. Systems that use HD computing to learn can run directly in memory and have been shown to be accurate, fast and very energy efficient. Most importantly, such systems can explain how they made decisions, resulting in devices that can learn directly from the data they obtain without the need for the cloud. In this talk I will present some of my team's recent work on hyperdimensional computing software and hardware infrastructure, including: i) novel algorithms supporting key cognitive computations in high-dimensional space such as classification, clustering, regression and others, ii) novel systems for efficient HD computing on sensors and mobile devices, which cover hardware accelerators such as GPUs, FPGAs and PIM, along with software infrastructure to support it. I will also present the prototypes my team built and tested, along with exciting results and some ideas for the next steps.

BIO: Tajana Šimunić Rosing's research interests are in energy efficient computing, cyber-physical and distributed systems. She recently headed the effort on SmartCities that was a part of DARPA and industry funded TerraSwarm center and the energy efficient datacenters theme in MuSyC center, and a number of large projects funded by both industry and government focused on power and thermal management. Tajana's instrumental works include proactive thermal management, ambient-driven thermal modeling, and event driven dynamic power management, which resulted in a number of industrial implementations and defined the framework for future researchers to approach these kinds of problems in embedded system design. From 1998 until 2005 she was a full time research scientist at HP Labs while also leading research efforts at Stanford University. She finished her PhD in EE in 2001 at Stanford. She has served at a number of Technical Paper Committees, including being an Associate Editor of IEEE Transactions on Mobile Computing, an Associate Editor of IEEE Transactions on Circuits and Systems, and a Guest Editor for the Special Issue of IEEE Transactions on VLSI.