AMAIN 2021

Applications of Machine Learning and Artificial Intelligence in Modern Networks

Special Track Introduction for ICDT 2021,
the 16th Int'l Conference on Digital Telecommunications
Porto, Portugal, April 18-22, 2021
(https://www.iaria.org/conferences2021/ICDT21.html)

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Track Chair

Stan McClellan, PhD
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Research Interests

- Speech/Signal/Image Processing and Analysis
- Topics in Communications and Information Theory
- Applications & Technologies in “Smart Cities” and “Smart Grid”
- Development and Validation of Multidisciplinary Applications

Publications & Activities

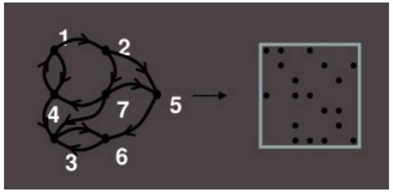
- Smart Cities in Application: Healthcare, Policy, and Innovation. Springer. 2019
- Smart Cities: Applications, Technologies, Standards and Driving Factors. Springer, 2017.
- The Smart Grid as an Application Development Platform. Artech House, 2017.
- “Smart City Applications,” IEEE GreenTech 2018, Apr. 2018.
- “The Smart Grid as an Application Deployment Platform,” IEEE GLOBECOM, 2014.
- “Cyber Security & Threat Management for the Smart Grid,” IEEE ICC, June 2012.
- “Security & Network Management in the Smart Grid,” 4th IEEE Computer & Communication Workshop (CCW), Oct. 2010.

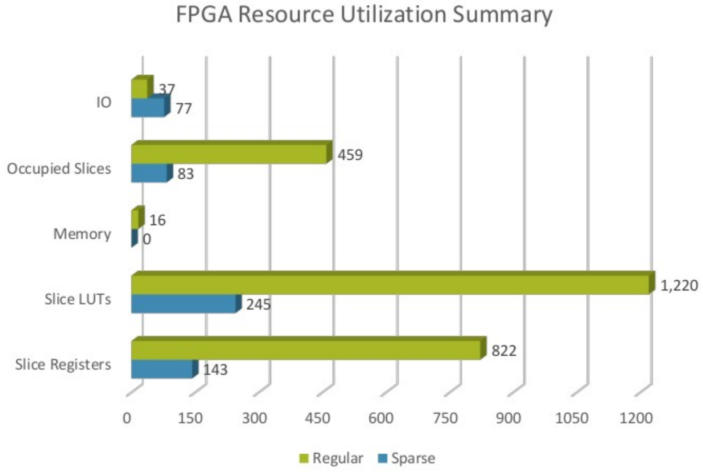
Track Focus

- The convergence of Machine Learning and Artificial Intelligence (ML/AI) with modern information networks (such as 5G wireless telecommunications) is enabling a new class of always-connected, multi-dimensional, and previously impossible applications.
- The data available from distributed sensors, probes, and embedded computing devices makes practical applications from situations that have heretofore been impossible to imagine.
- From fleets of LED-equipped drones and choreographed "fireworks" to network analysis and optimization, to real-time attitude and position of first responders, applications derived from ubiquitous network connectivity and enabled by ML/AI are becoming incredibly important.
- Similarly, comparisons of data acquisition & formatting as well as training / testing processes are critical to application successes.
- This special track focuses on the technologies, purposes, and architecture of such applications, with a particular interest in multi-disciplinary applications and practical relevance of the problems, enablers, comparisons, and outcomes.

Summary of Contributions (1/6)

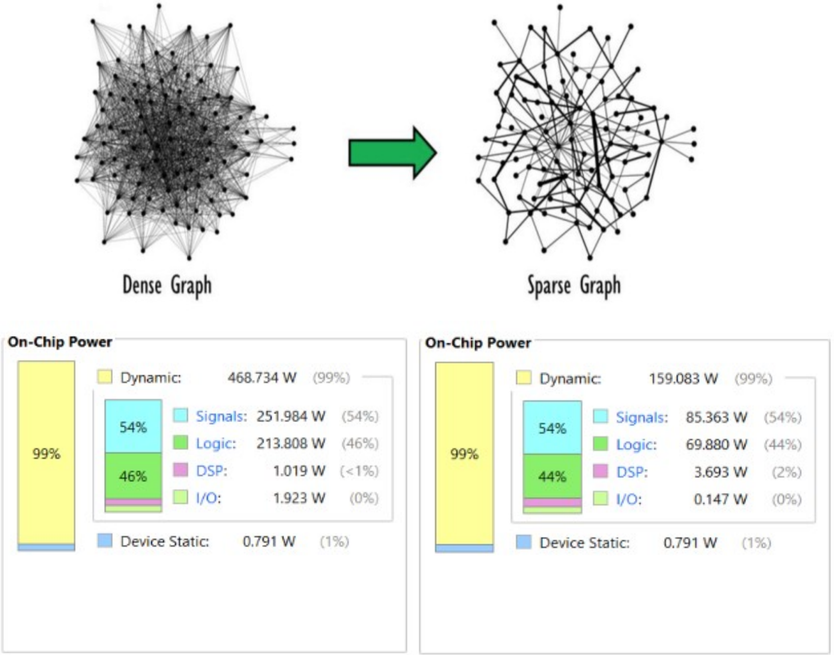
- Title:
  - Optimization of Sparse Matrix Arithmetic Operations and Performance Improvement using FPGA
- Authors:
  - D.K. Murthy, S. Aslan
- Summary:
  - Large datasets, which are popular in modern applications, and which are critical in ML/AI algorithms, are often stored in sparsely populated matrices.
  - Low temporal locality leads to inefficiencies in access, storage, and manipulation.
  - An algorithm is presented which minimizes critical resources (e.g. gate count, area, computational time, latency, etc.) while improving performance.
  - The algorithm decreases latency while increasing throughput for sparse matrix operations in an FPGA implementation.





Summary of Contributions (2/6)

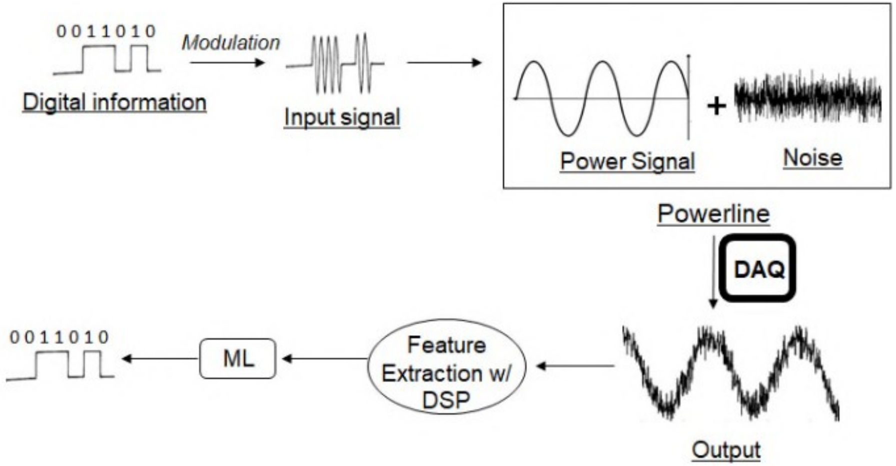
- Title:
  - Optimized Architecture for Sparse LU Decomposition on Matrices with Random Sparsity Patterns
- Authors:
  - D.K. Murthy, S. Aslan
- Summary:
  - Large sparse matrices often appear in scientific or engineering applications when solving partial differential equations.
  - Specialized algorithms and data structures are needed that take advantage of the sparse structure of the matrix
  - A design is presented with simple, scalable implementation and few input / output parameters
  - The architecture is generic and can be implemented irrespective of the application domain



Regular Method　　Proposed Method

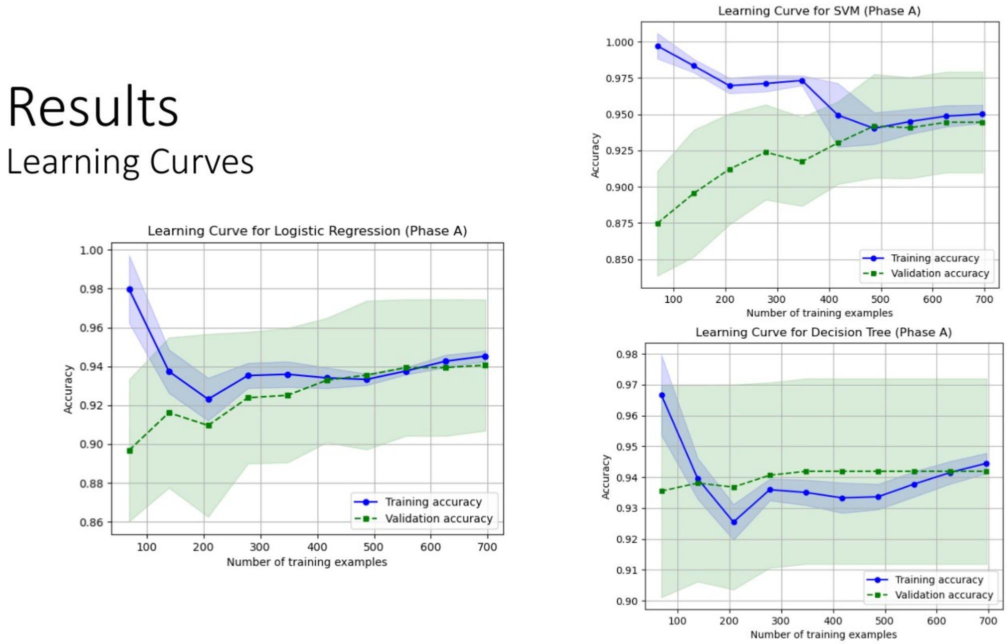
Summary of Contributions (3/6)

- Title:
  - IoT Applications with Common Distributed Architecture for Data Acquisition
- Authors:
  - K. Thapa, V. Lokesh, K. Seets
- Summary:
  - Multiple applications benefit from a "Coordinated IoT For Data Acquisition" (CIDAQ) architecture
  - Examples include training first responders, monitoring patients, tracking endangered species, power grid
  - Most IoT applications that leverage ML/AI implement a CIDAQ-style architecture
  - Hundreds of IoT start-ups as well as several Global 500 companies offer applications, services, tools



Summary of Contributions (4/6)

- Title:
  - Supervised Machine Learning in Digital Power Line Communications
- Authors:
  - K. Thapa, S. McClellan, D. Valles
- Summary:
  - Signal degradation in the power-grid makes demodulating PLC signals at the receiver difficult
  - Machine Learning (ML) can efficiently extract information carried by the communication signal
  - The paper compares the performance of ML algorithms such as SVM, Logistic Regression, Decision Tree, and ANN in demodulating PLC



Summary of Contributions (5/6)

- Title:
  - Remote Filesystem Event Notification and Processing for Distributed Systems
- Authors:
  - V. Lokesh, K. Thapa, S. McClellan
- Summary:
  - Monitoring remote filesystem events in a loosely coupled architecture can be difficult, but is often important in distributed applications
  - Local filesystem events can be monitored by several tools, such as inotify, Direvent, iWatch, Kqueue, FSEvents, etc.
  - The paper presents a simple, scalable, and efficient technique using multiplexed SSH and redirected inotify events which enables secure remote file system monitoring with minimum overhead

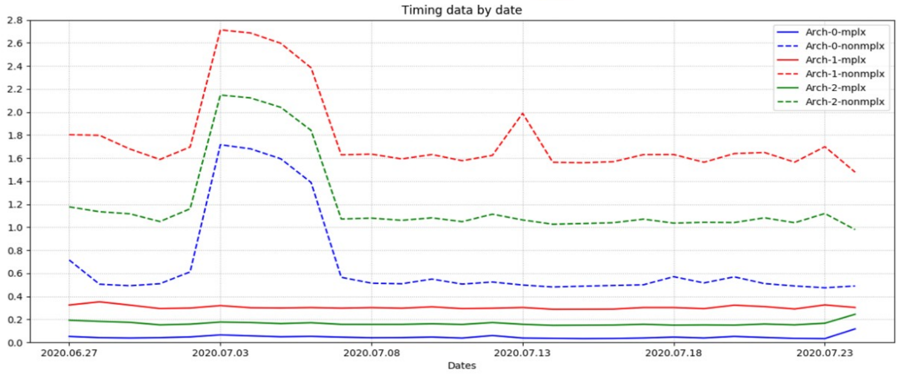
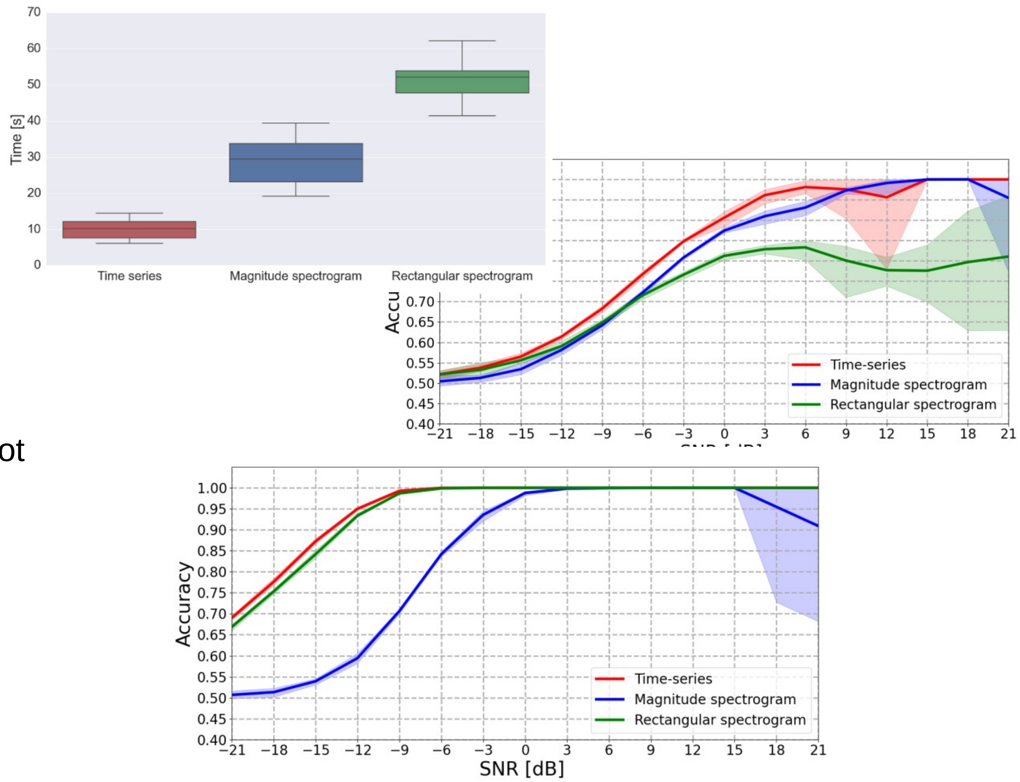


Figure 8. Timing data by date

Summary of Contributions (6/6)

- Title:
  - An Evaluation of Neural Network Performance Using Complex-Valued Input Data
- Authors:
  - K. Thapa, S. McClellan
- Summary:
  - Complex-valued data is common in many applications, including biomedical Imaging, seismic sensing, signal processing, and communications
  - Machine Learning algorithms and Neural Networks are not structured to use complex-valued data for training/testing
  - The paper compares different approaches to pre-processing complex-valued training data in conventional ML and NN scenarios, concluding that stacking real and imaginary components tends to perform better



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Conclusion & Future Work

- Big Data and Computation
  - Large datasets are prevalent in many contemporary applications. Hardware-assist is a common approach to offloading general-purpose CPUs in such cases (e.g. graphics processors and toolkits have been used successfully in many data-intensive applications)
  - The use of FPGA-driven offload engines may be appropriate for many datasets, and further research is needed to increase logic resources with a comparable increase in I/O bandwidth and on-chip memory, esp. for applications where sparse matrices are common.
- IOT Architectural Considerations
  - Many IoT-based applications share a common underlying system architecture which is essentially a heavily distributed, network-connected data acquisition system. Many unusual applications (e.g. endangered species monitoring) can benefit from such structures.
  - Efficient monitoring of filesystem events in such loosely coupled, distributed systems may be a more effective “publish/subsribe” bus or “message bus” than often-used and relatively heavy REST-driven APIs, and may provide better security (e.g. via multiplexed SSH).
- Machine Learning
  - Complex-valued data is used in many applications, and is a critical component of many prevalent ones, and other unusual ones (e.g. low-frequency power line communications). Unfortunately, most important ML algorithms and Neural Network constructs are not compatible with complex-valued input data.
  - Pre-processing complex-valued data in various ways (e.g. rectangular, polar, etc.) may produce different outcomes or efficiencies when using ML/AI algorithms which are not “aware” of complex numbers, or have not been constructed to handle complex-valued inputs.