# Charbel Sakr

PhD Candidate in ECE - University of Illinois at Urbana-Champaign

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## Education

- **University of Illinois at Urbana-Champaign** 2015-Present Illinois, USA
  - **PhD Candidate** in **Electrical and Computer Engineering** since May 2017.
  - **Masters of Science** in **Electrical and Computer Engineering** 2015-2017.

    **Thesis title**: *Analytical Guarantees for Reduced Precision Fixed-Point Margin Hyperplane Classifiers.*

    **Thesis Supervisor**: *Prof. N. Shanbhag.*

    **Graduating GPA**: **4.0**/4.
- **American University of Beirut** 2011-2015 Lebanon
  - **Bachelor** in **Engineering** (BE) in **Computer and Communications Engineering**

    **Graduating GPA**: **93.47**/100 (Equivalent to **4.0**/4).

    Recipient of a **Minor Mathematics** and a graduation **High Distinction**.

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## Research Experience

- **University of Illinois at Urbana-Champaign**
  - **Graduate Research Assistant** since the **Fall term 2015**, under the supervision of **Dr. Naresh Shanbhag**.
  - **Research interests**: I am broadly interested in **low-complexity**, **resource constrained Machine Learning** and **Signal processing**. A strong component of my research is in the understanding of **precision vs. accuracy trade-offs** in fixed-point learning systems, particularly, **deep neural networks**. I am also interested in low-cost *implementation* and *training* of neural networks, *statistical error compensation*, and *efficient memory systems.*
  - **Research Projects**

    **Fixed-point Neural Networks**: This work leverages the theory developed in my earlier work on fixed-point margin hyperplane classifiers. We showed that by leveraging the back-propagation algorithm, we can understand the trade-offs between accuracy and precision of fixed-point neural networks. I am the main contributor of this project. One paper on the topic has been published at the 2017 *International Conference on Machine Learning* (**ICML'17** [1]). A follow up work on this topic with a more fine-grained analysis and improved empirical results was published at the 2018 *International Conference on Acoustics, Speech, and Signal Processing* (**ICASSP'18** [2]).

    **Fixed-point Hyperplane Margin Classifiers**: This research seeks to bring rigor to the design of fixed-point learning systems which is currently being done using trial and error. Specifically we characterized the precision to accuracy trade-off of support vector machines (SVM) and general margin hyperplane classifiers. I am the lead contributor in this project. One paper on the topic has been published at the 2017 *International Conference*

*on Acoustics, Speech, and Signal Processing* (**ICASSP'17** [3]). An extension of this work with generalized results for hyperplane classifiers with non-linear input and output maps, as well as improved empirical results form the basis of my *Masters Thesis*.

**PredictiveNet**: This project proposes a simple but highly efficient architectural idea to reduce the computational cost of Convolutional Neural Networks (CNN). The idea is to decompose the arithmetic computation and predict sparse outputs efficiently. My contribution in this project was an analytical validation of the technique. One paper on the topic has been published at the 2017 *International Symposium on Circuits and Systems* (**ISCAS'17** [4]).

**Compute-Sensor**: This project aims to bring computation to the bitlines and cross-bitlines of a sensory array using mixed-signal techniques. My contribution was setting up the algorithm and validation dataset as well as post layout verifications.

- **IBM T. J. Watson Research Center**
  - **Research Intern** during the **Summer 2017** in the **Accelerator Architectures and Machine Learning** group.

    I worked under the supervision of **Dr. Kailash Gopalakrishnan**. The internship focused on the topic of training deep neural networks with reduced numerical precision. Specifically, I worked on a method to use true gradient based learning for binary activated network. Part of this work was published at the 2018 *International Conference on Acoustics, Speech, and Signal Processing* (**ICASSP'18** [5]).
- **University of Toronto**
  - **Research Intern** during the **Summer term 2014** under the supervision of **Dr. Farid Najm**.

    The research was on Computer-Aided Design (CAD) for integrated circuits. My work involved the development of techniques for macromodeling parts of an on-die power grid in order to ensure the safety on its internal nodes.

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## Awards

- **Best in Session Award** at **Techcon** 2017.
- **ECE Rambus Fellowship in Electrical and Computer Engineering** for 2018-2019.

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## Graduate Coursework

- **Digital IC Design**: Fall 2015 with *Prof. N. Shanbhag*: **A+**.
- **Graduate Level Digital Signal Processing**: Fall 2015 with *Prof. M. Do*: **A+**.
- **Analog IC Design**: Spring 2016 with *Prof. P. Hanumolu*: **A**.
- **Random Processes**: Spring 2016 with *Prof. V. Veeravalli*: **A+**.
- **Computational Inference and Learning**: Fall 2016 with *Prof. P. Moulin*: **A+**.
- **Machine Learning in Silicon**: Fall 2016 with *Prof. N. Shanbhag*: **A**.
- **Computational Complexity**: Spring 2017 with *Prof. A. Kolla*: **A**.
- **Statistical Learning Theory**: Spring 2017 with *Prof. B. Hajek*: **A**.
- **Learning Algorithms and Models**: Fall 2017 with *Prof. P. Viswanath*: **A**.
- **Computer Systems Organization**: Fall 2017 with *Prof. J. Torrellas*: **A**.

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## Skills

- **Languages**: English, French, and Arabic. All three spoken and written fluently.
- **Computer**: My favorite programming languages (which I use extensively) are Python and Matlab. I also have experience in C++, Verilog, Java, Haskell, Prolog, VHDL, Cadence. My all time favorite computer tool is LaTeX.

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## Publications


[1] C. Sakr, Y. Kim, and N. Shanbhag, "Analytical Guarantees on Numerical Precision of Deep Neural Networks," in *Proceedings of the 34th International Conference on Machine Learning*, pp. 3007–3016, 2017.

[2] C. Sakr and N. Shanbhag, "An Analytical Method to Determine Minimum Per-layer Precision of Deep Neural Networks," *International Conference on Accoustic, Speech, and Signal Processing (ICASSP)*, 2018.

[3] C. Sakr, A. Patil, S. Zhang, Y. Kim, and N. Shanbhag, "Minimum Precision Requirements for the SVM-SGD Learning Algorithm," *International Conference on Accoustic, Speech, and Signal Processing (ICASSP)*, 2017.

[4] Y. Lin, C. Sakr, Y. Kim, and N. Shanbhag, "PredictiveNet: An energy-efficient convolutional neural network via zero prediction," in *Circuits and Systems (ISCAS), 2017 IEEE International Symposium on*, pp. 1–4, IEEE, 2017.

[5] C. Sakr, J. Choi, Z. Wang, K. Gopalakrishnan, and N. Shanbhag, "True Gradient-based Training of Deep Binary Activated Neural Networks via Continuous Binarization," *International Conference on Accoustic, Speech, and Signal Processing (ICASSP)*, 2018.


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