

# **2021 IEEE/ACM International Symposium on Low Power Electronics and Design (ISLPED 2021)**

**Boston, Massachusetts, USA  
26 – 28 July 2021**



**IEEE Catalog Number: CFP21LOW-POD  
ISBN: 978-1-6654-3923-7**

**Copyright © 2021 by the Institute of Electrical and Electronics Engineers, Inc.  
All Rights Reserved**

*Copyright and Reprint Permissions:* Abstracting is permitted with credit to the source. Libraries are permitted to photocopy beyond the limit of U.S. copyright law for private use of patrons those articles in this volume that carry a code at the bottom of the first page, provided the per-copy fee indicated in the code is paid through Copyright Clearance Center, 222 Rosewood Drive, Danvers, MA 01923.

For other copying, reprint or republication permission, write to IEEE Copyrights Manager, IEEE Service Center, 445 Hoes Lane, Piscataway, NJ 08854. All rights reserved.

***\*\*\* This is a print representation of what appears in the IEEE Digital Library. Some format issues inherent in the e-media version may also appear in this print version.***

IEEE Catalog Number:	CFP21LOW-POD
ISBN (Print-On-Demand):	978-1-6654-3923-7
ISBN (Online):	978-1-6654-3922-0

**Additional Copies of This Publication Are Available From:**

Curran Associates, Inc  
57 Morehouse Lane  
Red Hook, NY 12571 USA  
Phone: (845) 758-0400  
Fax: (845) 758-2633  
E-mail: [curran@proceedings.com](mailto:curran@proceedings.com)  
Web: [www.proceedings.com](http://www.proceedings.com)

CURRAN ASSOCIATES INC.  
**proceedings**  
.com

# TABLE OF CONTENTS

CO-DESIGNING HARDWARE AND MODELS FOR EFFICIENT ON-DEVICE ML INFERENCE.....	1
<i>Matthew Mattina</i>	
HTNN: DEEP LEARNING IN HETEROGENEOUS TRANSFORM DOMAINS WITH SPARSE- ORTHOGONAL WEIGHTS .....	2
<i>Yu Chen, Bowen Liu, Pierre Abillama, Hun-Seok Kim</i>	
GESTURE-SNN: CO-OPTIMIZING ACCURACY, LATENCY AND ENERGY OF SNNs FOR NEUROMORPHIC VISION SENSORS .....	8
<i>Sonali Singh, Anup Sarma, Sen Lu, Abhronil Sengupta, Vijaykrishnan Narayanan, Chita R. Das</i>	
DIAN: DIFFERENTIABLE ACCELERATOR-NETWORK CO-SEARCH TOWARDS MAXIMAL DNN EFFICIENCY .....	14
<i>Yongan Zhang, Yonggan Fu, Weiwen Jiang, Chaojian Li, Haoran You, Meng Li, Vikas Chandra, Yingyan Lin</i>	
UNO: VIRTUALIZING AND UNIFYING NONLINEAR OPERATIONS FOR EMERGING NEURAL NETWORKS.....	20
<i>Di Wu, Jingjie Li, Setareh Behroozi, Younghyun Kim, Joshua San Miguel</i>	
DOSAGE: GENERATING DOMAIN-SPECIFIC ACCELERATORS FOR RESOURCE- CONSTRAINED COMPUTING .....	26
<i>Ankur Limaye, Tosiron Adegbija</i>	
ONLINE SOLAR ENERGY PREDICTION FOR ENERGY-HARVESTING INTERNET OF THINGS DEVICES.....	32
<i>Nuzhat Yamin, Ganapati Bhat</i>	
EEXNAS: EARLY-EXIT NEURAL ARCHITECTURE SEARCH SOLUTIONS FOR LOW- POWER WEARABLE DEVICES .....	38
<i>Mohanad Odema, Nafiu Rashid, Mohammad Abdullah Al Faruque</i>	
AN INSTRUCTION-LEVEL POWER AND ENERGY MODEL FOR THE ROCKET CHIP GENERATOR.....	44
<i>Zhiping Wang, W. Rhett Davis</i>	
POWER, PERFORMANCE, AREA AND COST ANALYSIS OF MEMORY-ON-LOGIC FACE- TO-FACE BONDED 3D PROCESSOR DESIGNS .....	50
<i>Anthony Agnesina, Moritz Brunion, Jinwoo Kim, Alberto Garcia-Ortiz, Dragomir Milojevic, Francky Catthoor, Manu Perumkunnil, Sung Kyu Lim</i>	
POWER DELIVERY AND THERMAL-AWARE ARM-BASED MULTI-TIER 3D ARCHITECTURE.....	56
<i>Lingjun Zhu, Tuan Ta, Rossana Liu, Rahul Mathur, Xiaoqing Xu, Shidhartha Das, Ankit Kaul, Alejandro Rico, Doug Joseph, Brian Cline, Sung Kyu Lim</i>	
PHO\$: A CASE FOR SHARED OPTICAL CACHE HIERARCHIES.....	62
<i>Haiyang Han, Theoni Alexoudi, Chris Vagionas, Nikos Pleros, Nikos Hardavellas</i>	

WHEN CLIMATE MEETS MACHINE LEARNING: EDGE TO CLOUD ML ENERGY EFFICIENCY .....	68
<i>Diana Marculescu</i>	
SPARTANSSD: A RELIABLE SSD UNDER CAPACITANCE CONSTRAINTS .....	69
<i>Hyeon Gyu Lee, Juwon Lee, Minwook Kim, Donghwa Shin, Sungjin Lee, Bryan S. Kim, Eunji Lee, Sang Lyul Min</i>	
RVO: UNLEASHING SSD'S PARALLELISM BY HARNESSING THE UNUSED POWER .....	75
<i>Hasan Alhasan, Yun-Chih Chen, Chien-Chung Ho</i>	
SRAM GAUGE: SRAM HEALTH MONITORING VIA CELLS RACE .....	81
<i>Nezam Rohbani, Masoumeh Ebrahimi</i>	
EFFICACY OF PRUNING IN ULTRA-LOW PRECISION DNNs .....	87
<i>Sanchari Sen, Swagath Venkataramani, Anand Raghunathan</i>	
ACME: AN ENERGY-EFFICIENT APPROXIMATE BUS ENCODING FOR I <sup>2</sup> C .....	93
<i>Chen Xie, Daniele Jahier Pagliari, Andrea Calimera, Enrico Macii, Massimo Poncino</i>	
55NM CMOS ANALOG CIRCUIT IMPLEMENTATION OF LIF AND STDP FUNCTIONS FOR LOW-POWER SNNs .....	99
<i>Zhitao Yang, Zhujiang Han, Yucong Huang, Terry Tao Ye</i>	
HOW MUCH ENERGY CAN WE HARVEST DAILY FOR WEARABLE APPLICATIONS? .....	105
<i>Yigit Tuncel, Toygun Basaklar, Umit Ogras</i>	
APPLICATION-DRIVEN DESIGN EXPLORATION FOR DENSE FERROELECTRIC EMBEDDED NON-VOLATILE MEMORIES .....	111
<i>Mohammad Mehdi Sharifi, Lillian Pentecost, Ramin Rajaei, Arman Kazemi, Qiuwen Lou, Guyeon Wei, David Brooks, Kai Ni, X. Sharon Hu, Michael Niemier, Marco Donato</i>	
LOW-POWER MULTI-CAMERA OBJECT RE-IDENTIFICATION USING HIERARCHICAL NEURAL NETWORKS .....	117
<i>Abhinav Goel, Caleb Tung, Xiao Hu, Haobo Wang, James C. Davis, George K. Thiruvathukal, Yung-Hsiang Lu</i>	
TCN MAPPING OPTIMIZATION FOR ULTRA-LOW POWER TIME-SERIES EDGE INFERENCE .....	123
<i>Alessio Burrello, Alberto Dequino, Daniele Jahier Pagliari, Francesco Conti, Marcello Zanghieri, Enrico Macii, Luca Benini, Massimo Poncino</i>	
PUFFIN: AN EFFICIENT DNN TRAINING ACCELERATOR FOR DIRECT FEEDBACK ALIGNMENT IN FEFET .....	129
<i>Fan Chen</i>	
A FLASH-BASED MULTI-BIT CONTENT-ADDRESSABLE MEMORY WITH EUCLIDEAN SQUARED DISTANCE .....	135
<i>Arman Kazemi, Shubham Sahay, Ayush Saxena, Mohammad Mehdi Sharifi, Michael Niemier, X. Sharon Hu</i>	
COPIM: A CONCURRENCY-AWARE PIM WORKLOAD OFFLOADING ARCHITECTURE FOR GRAPH APPLICATIONS .....	141
<i>Liang Yan, Mingzhe Zhang, Rujia Wang, Xiaoming Chen, Xingqi Zou, Xiaoyang Lu, Yinhe Han, Xian-He Sun</i>	

MC <sup>2</sup> -RAM: AN IN-8T-SRAM COMPUTING MACRO FEATURING MULTI-BIT CHARGE-DOMAIN COMPUTING AND ADC-REDUCTION WEIGHT ENCODING .....	147
<i>Zhiyu Chen, Qing Jin, Jingyu Wang, Yanzhi Wang, Kaiyuan Yang</i>	
ENABLING ROBUST SOT-MTJ CROSSBARS FOR MACHINE LEARNING USING SPARSITY-AWARE DEVICE-CIRCUIT CO-DESIGN .....	153
<i>Tanvi Sharma, Cheng Wang, Amogh Agrawal, Kaushik Roy</i>	
SPACE-EFFICIENT GRAPH DATA PLACEMENT TO SAVE ENERGY OF RERAM CROSSBAR .....	159
<i>Ting-Shan Lo, Chun-Feng Wu, Yuan-Hao Chang, Tei-Wei Kuo, Wei-Chen Wang</i>	
WEARABLE DEVICES AND LOW-POWER DESIGN FOR SMART HEALTH APPLICATIONS: CHALLENGES AND OPPORTUNITIES .....	165
<i>Toygun Basaklar, Yigit Tuncel, Sizhe An, Umit Ogras</i>	
POWER-AWARE HEART RATE MONITORING USING PARTICLE FILTERS .....	166
<i>Ali Akbari, Roozbeh Jafari</i>	
WIRELESS POWER TRANSFER AND DATA COMMUNICATION FOR LOW-POWER MICRO ELECTRONIC DEVICES DEEPLY IMPLANTED WITHIN THE HUMAN BODY .....	167
<i>Mingui Sun, Qi Xu, Tianfeng Wang, Shitong Mao, Gusphyl A. Justin, Wenyan Jia, Zhi-Hong Mao</i>	
ACTIVE CELL BALANCING FOR LIFE CYCLE EXTENSION OF LITHIUM-ION BATTERIES UNDER THERMAL GRADIENT .....	168
<i>Philipp Kremer, Francesco Cigarini, Dietmar Göhlich, Sangyoung Park</i>	
A HIGH-PERFORMANCE LOW-POWER BARRETT MODULAR MULTIPLIER FOR CRYPTOSYSTEMS .....	174
<i>Bo Zhang, Zeming Cheng, Massoud Pedram</i>	
BEACON: BEST APPROXIMATIONS FOR COMPLETE BEHAVIORAL HETEROGENEOUS SOCS .....	180
<i>Prattay Chowdhury, Benjamin Carrion Schafer</i>	
STATISTICAL OPTIMIZATION OF COMPUTE IN-MEMORY PERFORMANCE UNDER DEVICE VARIATION .....	186
<i>Brian Crafton, Samuel Spetalnick, Jong-Hyeok Yoon, Arijit Raychowdhury</i>	
MIMHD: ACCURATE AND EFFICIENT HYPERDIMENSIONAL INFERENCE USING MULTI-BIT IN-MEMORY COMPUTING.....	192
<i>Arman Kazemi, Mohammad Mehdi Sharifi, Zhuowen Zou, Michael Niemier, X. Sharon Hu, Mohsen Imani</i>	
FPRA: A FINE-GRAINED PARALLEL RRAM ARCHITECTURE.....	198
<i>Xiao Liu, Minxuan Zhou, Rachata Ausavarungnirun, Sean Eilert, Ameen Akel, Tajana Rosing, Vijaykrishnan Narayanan, Jishen Zhao</i>	

## **Author Index**