

# **2025 IEEE 55th International Symposium on Multiple-Valued Logic (ISMVL 2025)**

**Montreal, Quebec, Canada  
5-6 June 2025**



**IEEE Catalog Number: CFP25034-POD**  
**ISBN: 979-8-3315-0745-9**

**Copyright © 2025 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:	CFP25034-POD
ISBN (Print-On-Demand):	979-8-3315-0745-9
ISBN (Online):	979-8-3315-0744-2
ISSN:	0195-623X

**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

# 2025 IEEE 55th International Symposium on Multiple- Valued Logic (ISMVL) **ISMVL 2025**

## Table of Contents

Message from the General Chairs .....	x
Message from Program Chairs .....	xi
Symposium Committee .....	xii
Program Committee .....	xiii
Reviewers .....	xiv

### Special Session on Spin-Edge Computing I

Probabilistic Computing Utilizing Stochastic Spintronic Devices .....	1
<i>Shunsuke Fukami (Tohoku University, Japan; Inamori Research Institute of Science, Japan)</i>	
Implementation of an MRAM-Based Edge AI Hardware with a Fine-Grained Power-Gating Technique .....	4
<i>Tomohiro Yoneda (Tohoku University, Japan), Yasuhiro Takako (Tohoku University, Japan), Akira Tamakoshi (Tohoku University, Japan), Masanori Natsui (Tohoku University, Japan), Daisuke Suzuki (The University of Aizu, Japan), and Takahiro Hanyu (Tohoku University, Japan)</i>	
Intelligent Power-Gating Technique with Quick Wake-Up/Sleep Functionality for Spintronics-Based Edge Computing Hardware .....	10
<i>Fangcen Zhong (Tohoku University, Japan), Masanori Natsui (Tohoku University, Japan), and Takahiro Hanyu (Tohoku University, Japan)</i>	
Enhanced Simulated Bifurcation for MIMO Detection .....	15
<i>Ryan Seah (McGill University, Canada), Tingting Zhang (McGill University, Canada), and Warren J. Gross (McGill University, Canada)</i>	

### Non Classical Logics

Multi-Valued Models for Intuitionistic Logic .....	21
<i>Alexander Sakharov (Synstretch, USA)</i>	
On Many-Valued Modal Probabilistic Logics .....	26
<i>Ondrej Majer (Czech Academy of Sciences, The Czech Republic) and Igor Sedlár (Czech Academy of Sciences, The Czech Republic)</i>	

A Predicate Variant of Two-Layered Many-Valued Probability Logic .....	32
<i>Libor Běhounek (University of Ostrava, Czechia)</i>	
A Complete Tableau Calculus for Signed MaxSAT .....	38
<i>Jordi Coll (Universitat de Girona, Spain), Chu Min Li (Université de Picardie, France), Felip Manyà (Artificial Intelligence Research Institute (IIIA, CSIC), Spain), and Elifnaz Yangin (Artificial Intelligence Research Institute (IIIA, CSIC), Spain)</i>	

## Keynote Address

Contributions of K. C. Smith in Applications of Multiple-Valued Logic .....	44
<i>Zeljko Zilic (McGill University, Canada)</i>	

## KC Smith Special Session I

Memories of K. C. Smith: Analog Computing, Multiple-Valued Logic and Machine Learning .....	50
<i>Vincent Gaudet (University of Waterloo, Canada)</i>	
Hardware-Compatible U-Net for Low-Dose PET Reconstruction .....	51
<i>Eric-Khang Dao (University of Waterloo, Canada), Katherine Zukotynski (McMaster University, Canada), Sandra E. Black (University of Toronto, Canada), and Vincent Gaudet (University of Waterloo, Canada)</i>	
Energy-Efficient Automated Seizure Detection in Wearable/Implantable BCIs: Motivations, Methods, and Example Implementation .....	57
<i>Alireza Dabbaghian (York University, Canada) and Hossein Kassiri (York University, Canada)</i>	
Delta-Sigma Modulated Noise-Shaping Bitstreams for Multilayer Perceptron .....	63
<i>Takao Waho (Sophia University, Japan), Akihisa Koyama (Sophia University, Japan), and Hitoshi Hayashi (Sophia University, Japan)</i>	

## Special Session on Spin-Edge Computing II

Analog CMOS Spiking Neural Network for Time-Series Signal Recognition .....	69
<i>Shigeo Sato (Tohoku University, Japan), Satoshi Moriya (Tohoku University, Japan), Masaya Ishikawa (Tohoku University, Japan), and Hideaki Yamamoto (Tohoku University, Japan)</i>	
An FPGA-Based Rapid-Prototyping Platform for Spintronics-Based Edge-Computing Hardware ....	70
<i>Daisuke Suzuki (The University of Aizu, Japan), Akira Tamakoshi (Tohoku University, Japan), Tomohiro Yoneda (Tohoku University, Japan), Masanori Natsui (Tohoku University, Japan), Yasuhiro Takako (Tohoku University, Japan), and Takahiro Hanyu (Tohoku University, Japan)</i>	
Simulation and Evaluation of Asynchronous Circuits in Extreme Edge Environments .....	74
<i>Masashi Imai (Hirosaki University, Japan)</i>	

Generating Hamiltonians with Known Minimum Energy Based on Ground-State Spin Logic for Probabilistic-Bit-Based Simulated Annealing .....	80
<i>Naoya Onizawa (Tohoku University, Japan) and Takahiro Hanyu (Tohoku University, Japan)</i>	

## Emerging Applications

Binarization and Classification of RGB Images .....	86
<i>Tagir Nukenov (Hiroshima City University, Japan), Kamila Abdiyeva (University of Illinois Urbana-Champaign, USA), Oliver Keszocze (Technical University of Denmark, Denmark), Shinobu Nagayama (Hiroshima City University, Japan), and Martin Lukac (Hiroshima City University, Japan)</i>	
MUSIC Spectra using Cayley Graphs of Multiple-Valued Signals .....	92
<i>Aviraj Sinha (Southern Methodist University, USA), Darrell Young (Southern Methodist University, USA), Eric C. Larson (Southern Methodist University, USA), and Mitchell A. Thornton (Southern Methodist University, USA)</i>	
REBEL-6: A 32-Trit Balanced Ternary Instruction Set Architecture with R2R Compiler Pipeline for C .....	98
<i>Steven Bos (University of South-Eastern Norway, Norway), Vetle Bodahl (University of South-Eastern Norway, Norway), Ole Christian Moholth (University of South-Eastern Norway, Norway), and Henning Gundersen (University of South-Eastern Norway, Norway)</i>	

## Quantum Computing

Reducing the Cost of Clifford+T Quantum Gates .....	104
<i>Takehiro Ishioka (Hiroshima City University, Japan), Martin Lukac (Hiroshima City University, Japan), and Shinobu Nagayama (Hiroshima City University, Japan)</i>	
Realizing 4-Input Functions with the Minimum Toffoli Gate Count .....	110
<i>Shigeru Yamashita (Ritsumeikan University), Takashi Horiyama (Hokkaido University), Norihito Yasuda (NTT Corporation), and Tatsuya Nakao (Ritsumeikan University)</i>	
A Novel Data Representation Towards Efficient FPGA-Based Quantum Computer Simulation .....	117
<i>Haruhiko Hasegawa (Institute of Science Tokyo, Japan), Masayuki Shimoda (Institute of Science Tokyo, Japan), Hiroki Nakahara (Tohoku University, Japan), and Takefumi Miyoshi (WasaLabo, LLC., Japan)</i>	
Modeling and Simulation of Multiple-Valued and Nonlinear Quantum Photonic Components .....	123
<i>Joshua Ange (Southern Methodist University, USA), Mason Tuller (Southern Methodist University, USA), Jessie M. Henderson (Southern Methodist University, USA), Elena R. Henderson (Southern Methodist University, USA), Bradley A. Moores (Leidos Corporation, USA), Duncan L. MacFarlane (Southern Methodist University, USA), and Mitchell A. Thornton (Southern Methodist University, USA)</i>	

## Security

Hybrid Fingerprinting for Effective Detection of Cloned Neural Networks .....	129
<i>Can Aknesil (KTH Royal Institute of Technology, Sweden), Elena Dubrova (KTH Royal Institute of Technology, Sweden), Niklas Lindskog (Ericsson AB, Sweden), Jakob Sternby (Ericsson AB, Sweden), and Håkan Englund (Ericsson AB, Sweden)</i>	
Decompressing Dilithium's Public Key with Fewer Signatures using Side Channel Analysis .....	135
<i>Ruize Wang (KTH Royal Institute of Technology, Sweden), Joel Gärtner (KTH Royal Institute of Technology, Sweden), and Elena Dubrova (KTH Royal Institute of Technology, Sweden)</i>	
Is Your Chip Leaking Secrets via RF Signals? .....	141
<i>Yanning Ji (KTH Royal Institute of Technology, Sweden), Elena Dubrova (KTH Royal Institute of Technology, Sweden), and Ruize Wang (KTH Royal Institute of Technology, Sweden)</i>	
Solving AES-SAT using Side-Channel Hints: A Practical Assessment .....	147
<i>Elena Dubrova (KTH Royal Institute of Technology, Sweden)</i>	

## Logic Design

Representation of Rotation Symmetric Multiple-Valued Functions using Decision Diagrams .....	153
<i>Shinobu Nagayama (Hiroshima City University, Japan), Tsutomu Sasao (Meiji University, Japan), Jon T. Butler (Naval Postgraduate School, Japan), and Martin Lukac (Hiroshima City University, Japan)</i>	
Linear Transformations for Iterative Reduction of Variables .....	160
<i>Tsutomu Sasao (Meiji University, Japan)</i>	
Normal Forms and Decompositions of Monotone Ternary Functions .....	166
<i>Klaus Schneider (RPTU University Kaiserslautern-Landau, Germany) and Nadine Kercher (RPTU University Kaiserslautern-Landau, Germany)</i>	
Additive Decomposition of Bent Functions .....	172
<i>Claudio Moraga (Technical University of Dortmund, Germany), Radomir S. Stanković (S.A.S.A., Serbia), and Milena Stanković (Faculty of Electronic Engineering, Serbia)</i>	
Multi-Input MAGIC Synthesis and Verification for In-Memory Computing Design .....	178
<i>Saeideh Nabipour (German Research Centre for Artificial Intelligence (DFKI), Germany), Kamalika Datta (German Research Centre for Artificial Intelligence (DFKI), Germany; University of Bremen, Germany), Lennart Weingarten (University of Bremen, Germany), Abhoy Kole (German Research Centre for Artificial Intelligence (DFKI), Germany), and Rolf Drechsler (German Research Centre for Artificial Intelligence (DFKI), Germany; University of Bremen, Germany)</i>	

## Algebra, Clone, & Logic

All Minimal Clones Generated by $\{0, 1\}$ -Valued Majority Operations on a Five-Element Set .....	184
<i>Mike Behrisch (Technische Universität Wien, Austria), Edith Vargas-García (Instituto Tecnológico Autónomo de México, Mexico), and Andreas Wachtel (Instituto Tecnológico Autónomo de México, Mexico)</i>	

On 2-Valued Majority Functions with Their Relation to Minimal Clones .....	190
<i>Hajime Machida (Hitotsubashi University, Japan)</i>	
Foullis $m$ -semilattices and their Modules .....	196
<i>Michal Botur (Palacký University Olomouc, Czech Republic), Jan Paseka (Masaryk University, Czech Republic), and Milan Lekár (Masaryk University, Czech Republic)</i>	
Cut Elimination and Normalization in Intermediate Connexive Logics .....	202
<i>Norihiro Kamide (Nagoya City University, Japan)</i>	
Normalization Theorem for Extended Intuitionistic Belnap–Dunn Logic .....	208
<i>Norihiro Kamide (Nagoya City University, Japan)</i>	

## KC Smith Special Session II

On the Contributions to Multiple-Valued Logic by Prof. Kenneth C. Smith .....	214
<i>D. Michael Miller (University of Victoria, Canada)</i>	
Multi-Valued Data Transmission System using Mild Waveform Shaping Based on Multi-Dimensional Symbol Mapping .....	217
<i>Yosuke Iijima (Oyama College, Japan), Atsunori Okada (Oyama College, Japan), and Yasushi Yuminaka (Gunma University, Japan)</i>	
Visualization of the Waveform Shaping Effect of Higher-Order FFEs using Multi-Valued Symbol Mapping .....	223
<i>Yasushi Yuminaka (Gunma University, JAPAN), Ryou Andachi (Gunma University, JAPAN), Haohao Zhang (Gunma University, JAPAN), and Yosuke Iijima (Oyama College, JAPAN)</i>	
<b>Author Index</b> .....	<b>229</b>