

IWLS 2025

Programming Contest

Alan Mishchenko Alessandro Tempia Calvino



Overview

- Node minimization, continued from 2022 to this year
 - Given a Boolean function as a truth table, find a minimal circuit
- One track: minimizing AIG nodes
 - 100 testcases from the IWLS 2022 contest
 - New 100 practical testcases
- Our plan for today
 - Introduce the participants
 - Review the problems
 - Show the results
 - Congratulate the winners!

Participants

- University of California Berkeley and National Taiwan University
 - Yukio Miyasaka, Jiun-Hao Chen
 - EPFL, JetBrains, and Neapolis University Pafos
 - Stanislav Alekseev, Timur Degteari, Gregory Emdin, Mikhail Goncharov, Ilia Kondakov, Alexander S. Kulikov, Fedor Kurmazov, Maksim Levitskii, Georgii Levtsov, Maksim Shevkoplias, Roman Shumilov
 - UCLA
 - Hanyu Wang, Chengdi Cao, Wan-Hsuan Lin, Jason Cong
 - University of Freiburg and University of Liverpool
 - Franz-Xaver Reichl, Friedrich Slivovsky
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IWLS 2022 Problems

- We reused testcases from the IWLS 2022 contest
- 2024 contest results showed large improvements compared to previous years
- The following table shows the function of each testcase in 2022 numbering

Examples	Description
ex00 - ex01	Known random-looking functions
ex02 - ex07	Random and modified random functions
ex08 - ex09	s-box and inverse s-box from AES [1]
ex10 - ex15	5-input through 15-input majority functions
ex16 - ex27	N-input N-output binary sorters
ex28 - ex49	Selected Espresso benchmarks with permuted inputs
ex50 - ex67	Arithmetic functions with permuted inputs / dropped outputs
ex68 - ex99	Three-output neurons from the LogicNets project [2]

[1] https://en.wikipedia.org/wiki/Rijndael_S-box

[2] Y. Umuroglu et al., "LogicNets: Co-designed neural networks and circuits for extreme-throughput applications," Proceedings of FPL 2020, pp. 291–297. <https://github.com/Xilinx/logicnets>

IWLS 2025 Problems

- 100 new practical circuits
- The following table shows the function of each new testcase

Examples	Description
ex100 – ex119	Five different data-dependent bit-permutation functions (4 bit-widths)
ex120 – ex124	Multipliers
ex125 – ex129	Modular multipliers
ex130 – ex134	Dividers
ex135 – ex139	Hypothenuse circuits
ex140 – ex144	Squarers
ex145 – ex149	Square rooters
ex150 – ex159	RNS to binary converters [3]
ex160 – ex179	Two-arg minifloat op. (add, mul, div, hyp, pow of 125,134, 143, 152)
ex180 – ex189	One-arg FP16 op. ($1/x$, $1/x^2$, etc., sqrt, sin, cos, sigmoid, swish)
ex190 – ex199	One-arg BF16 op. ($1/x$, $1/x^2$, etc., sqrt, sin, cos, sigmoid, swish)

[3] H. Nakahara and T. Sasao, "A deep convolutional neural network based on nested residue number system", Proc. FPL'15.

IWLS 2022 Problems

- The score on a set of testcases is defined as the sum of scores for each testcase. For all the participants who correctly solved a testcase, the score of a testcase is equal to $100 * \frac{\text{cost_of_best_solution}}{\text{cost_of_this_solution}}$, where a solution cost is determined as the number of two-input AND nodes in the AIG.

	team1	team2	team3	team4
total nodes	19493	18990	19270	20345
wins	48	86	62	52
uniq. wins	0	33	9	5
score	9727.75	9949.23	9816.11	9554.48

IWLS 2025 Problems

	team1	team2	team3	team4
total nodes	548234	214691	410337	930189
wins	11	68	22	13
uniq. wins	11	57	18	4
score	6593.62	9432.99	7393.61	6058.40

Total Score

- Total score = 4 * Score(IWLS22) + Score(IWLS25)

	team1	team2	team3	team4
Total score	45504.61	49229.93	46658.05	44276.33

Comparison with Past Results

AIG IWLS 2022	2022 virtual best	2023 virtual best	2024 virtual best	2025 virtual best
total nodes	27727	23439	19653	18990
geomean of ratios	1.411	1.193	1.000	0.966

Breakdown Improvement IWLS 2022

Examples	Description	2023 virtual best total nodes	2024 virtual best total nodes	2025 virtual best total nodes	Diff w.r.t. 2024
ex00 – ex01	random-looking functions	46	44	44	0
ex02 – ex07	random functions	1605	1404	1365	-39
ex08 – ex09	s-box functions	1066	1005	920	-85
ex10 – ex15	majority functions	220	218	218	0
ex16 – ex27	binary sorters	781	720	716	-4
ex28 – ex49	ESPRESSO benchmarks	4315	4069	3932	-137
ex50 – ex67	custom arithmetic functions	9288	6530	6336	-194
ex68 – ex99	quantized neuron functions	6118	5663	5242	-421

Winners

- 3rd place: EPFL, JetBrains, and Neapolis University Pafos
 - Stanislav Alekseev, Timur Degteari, Gregory Emdin, Mikhail Goncharov, Ilia Kondakov, Alexander S. Kulikov, Fedor Kurmazov, Maksim Levitskii, Georgii Levtsov, Maksim Shevkoplias, Roman Shumilov
- 2nd place: University of Freiburg and University of Liverpool
 - Franz-Xaver Reichl, Friedrich Slivovsky
- 1st place: University of California Berkeley and National Taiwan University
 - Yukio Miyasaka, Jiun-Hao Chen