Machine Learning for High-Fidelity Design Prediction and Automatic Tuning

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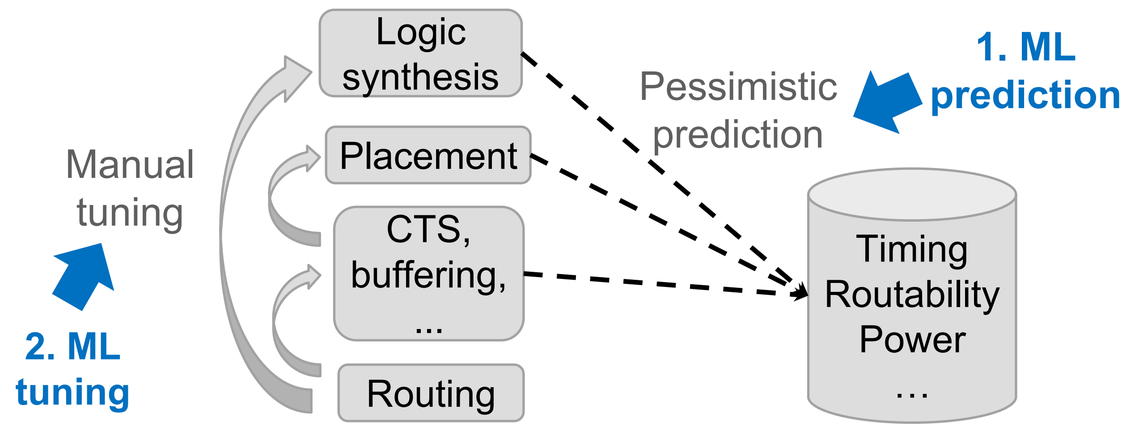
INTRODUCTION

Challenges in traditional EDA

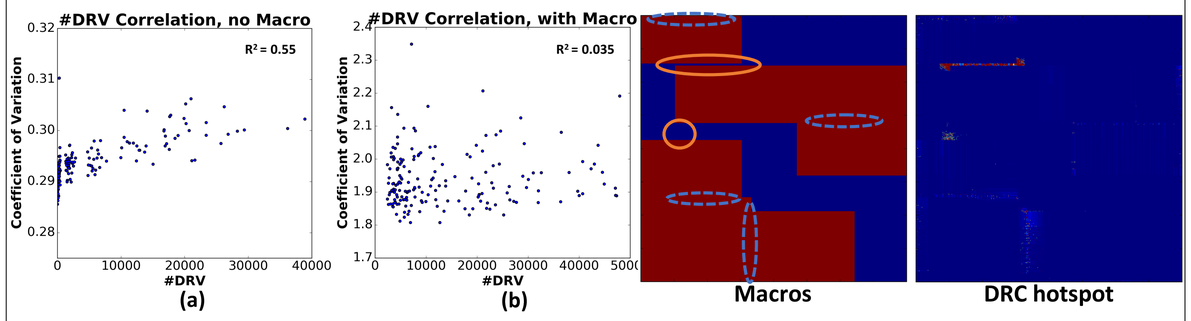
Tools restricted to own stage → Pessimistic estimations at early stage → 1. Long turn-around time

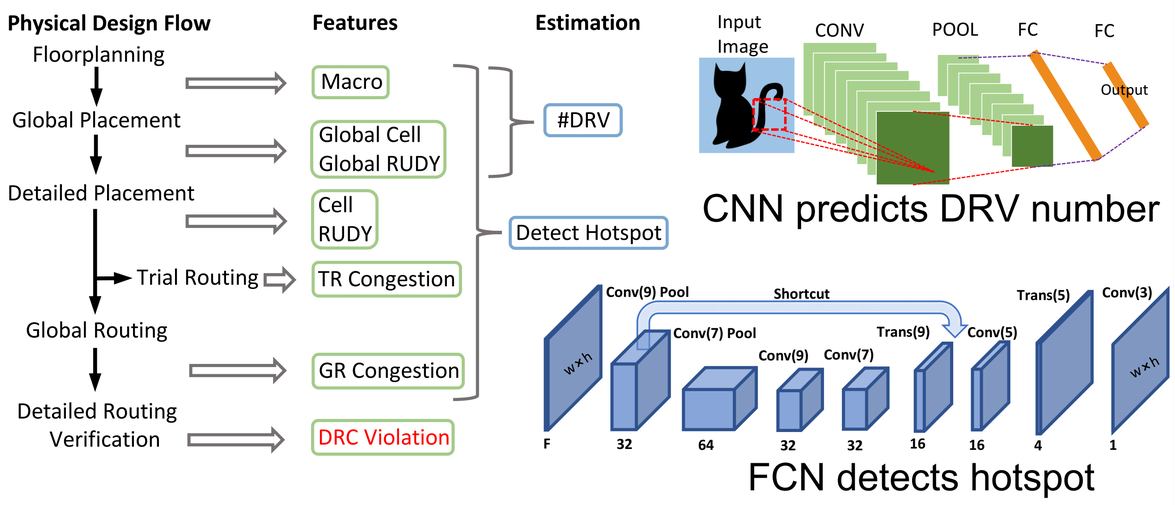
Rely on human tuning → Stringent requirement on designer experience → 2. Engineer expense



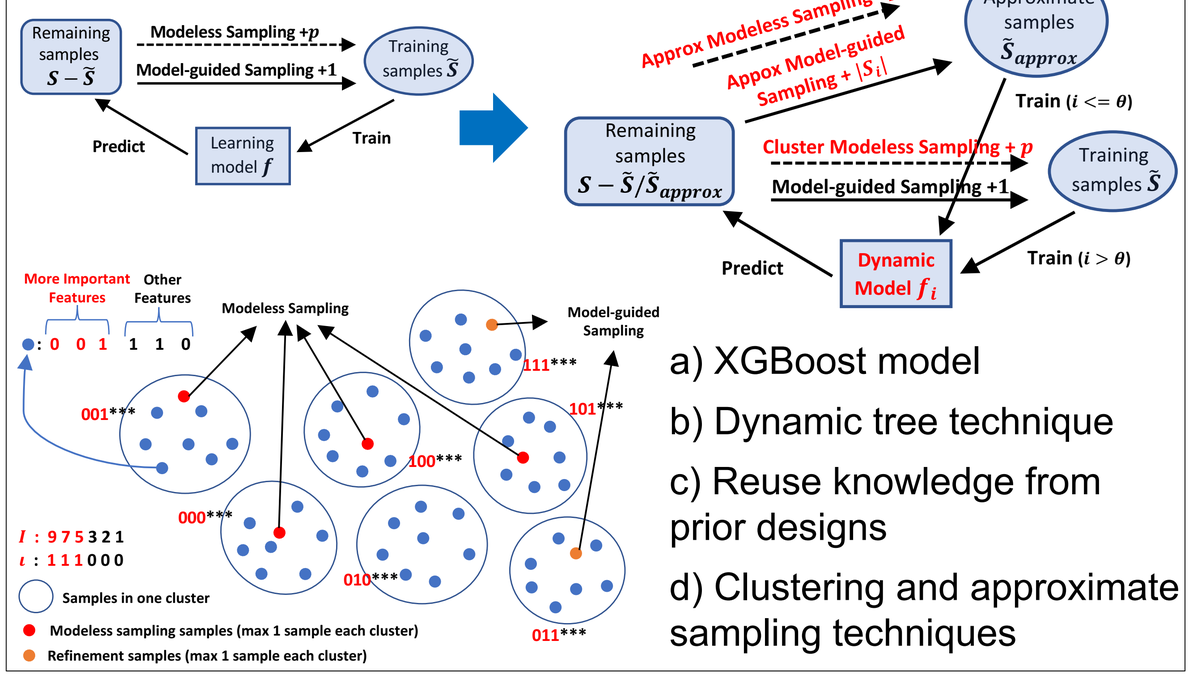
METHODS

1. **RouteNet**: **Rout**ability Prediction for Mixed-Size Designs Using Convolutional Neural **Net**work





2. **FIST**: A **F**eature-**I**mportance **S**ampling and **T**ree-Based Method for Automatic Design Flow Parameter Tuning



a) XGBoost model

b) Dynamic tree technique

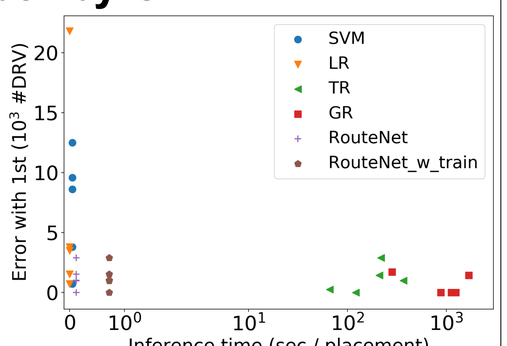
c) Reuse knowledge from prior designs

d) Clustering and approximate sampling techniques

ROUTABILITY PREDICTION RESULT

Routability prediction by DRV number by CNN

Circuit Name	$c_0/c_1+c_2+c_3$ accuracy (%)					Best rank in top 10				
	SVM	LR	TR	GR	Route Net	SVM	LR	TR	GR	Route Net
des_perf	63	74	80	77	80	87^{th}	15^{th}	2^{nd}	1^{st}	2^{nd}
edit_dist	69	68	78	77	76	17^{th}	17^{th}	3^{rd}	3^{rd}	2^{nd}
fft	66	62	73	70	75	6^{th}	6^{th}	2^{nd}	33^{rd}	1^{st}
matrix_mult_a	66	65	78	74	72	30^{th}	5^{th}	1^{st}	1^{st}	5^{th}
matrix_mult_b	63	62	76	73	76	22^{nd}	93^{rd}	4^{th}	1^{st}	4^{th}
Average	65	66	77	74	76	32^{nd}	27^{th}	2^{nd}	8^{th}	3^{rd}



RouteNet is the only fast and accuracy method that predicts DRV num.

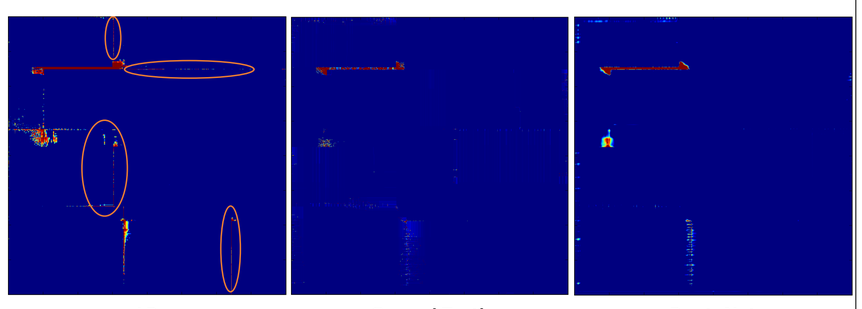
DRV hotspot detection by FCN

Label	Prediction Result: Positive	Prediction Result: Negative
Positive	TP	FN
Negative	FP	TN

Evaluation

$$TPR = \frac{TP}{TP + FN}$$

$$FPR = \frac{FP}{FP + TN}$$



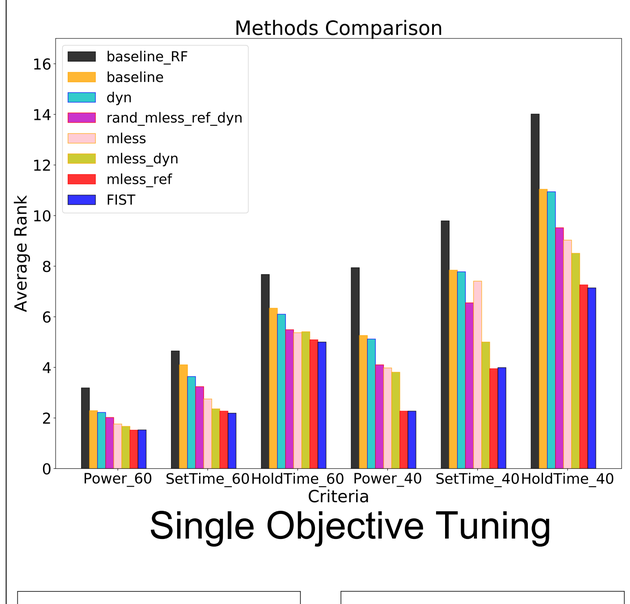
Circuit Name	FPR (%)	TPR (%)				
		TR	GR	LR	SVM	RouteNet
des_perf	0.54	17	56	54	42	74
edit_dist	1.00	25	36	38	28	64
fft	0.30	21	45	54	31	71
matrix_mult_a	0.21	13	30	34	12	49
matrix_mult_b	0.24	13	37	41	20	53
Average	0.46	18	41	44	27	62

Circuit Name	FPR (%)	TPR (%)					
		Infer seen	Less data	No short	Less conv	No pool	Route Net
des_perf	0.54	77	71	71	73	68	74
edit_dist	1.00	68	61	63	62	55	64
fft	0.30	74	70	68	68	69	71
matrix_mult_a	0.21	51	46	45	45	45	49
matrix_mult_b	0.24	58	50	51	50	50	53
Average	0.46	66	60	60	60	57	62

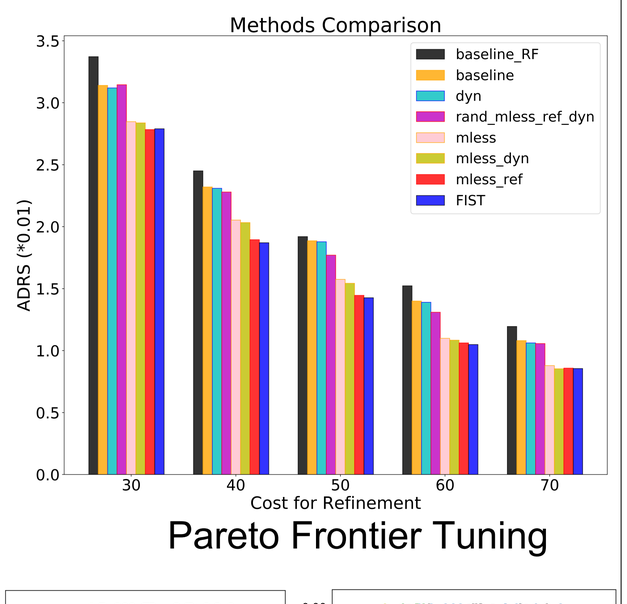
Importance of large receptive region and global information.

AUTOMATIC TUNING RESULT

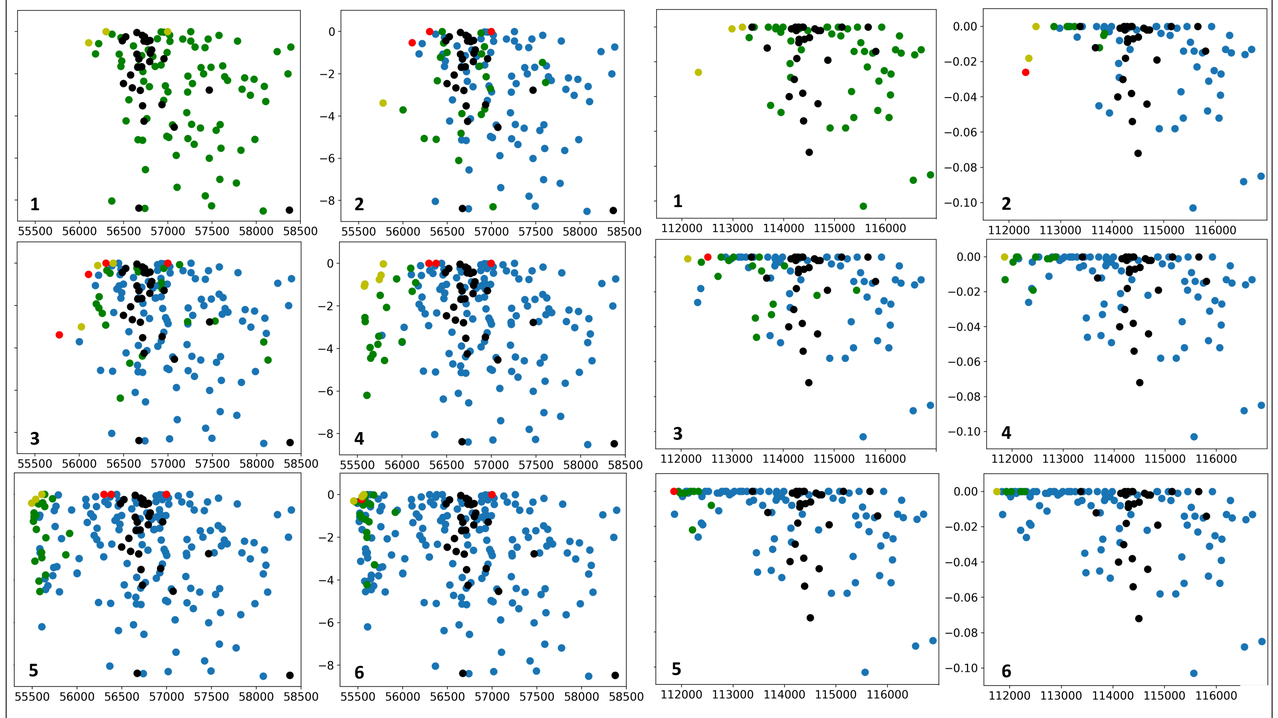
The design quality of best explored parameter sets



Single Objective Tuning



Pareto Frontier Tuning



Parameter tuning process in six stages on two industrial designs. Area (μm²) vs. setup TNS (ns). **Red** and **yellow** are Pareto points. **Black** are baselines from designer.