2021 IWLS Programming Contest: Team NTU-ALCOM

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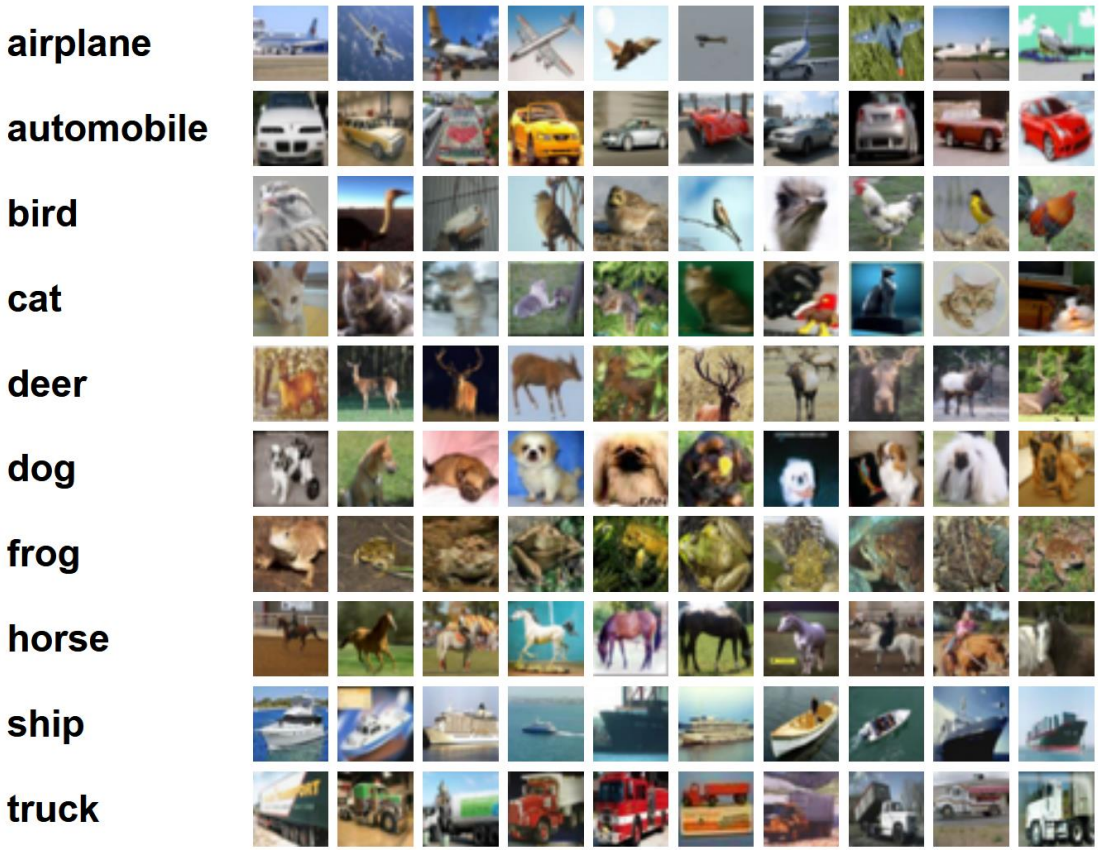
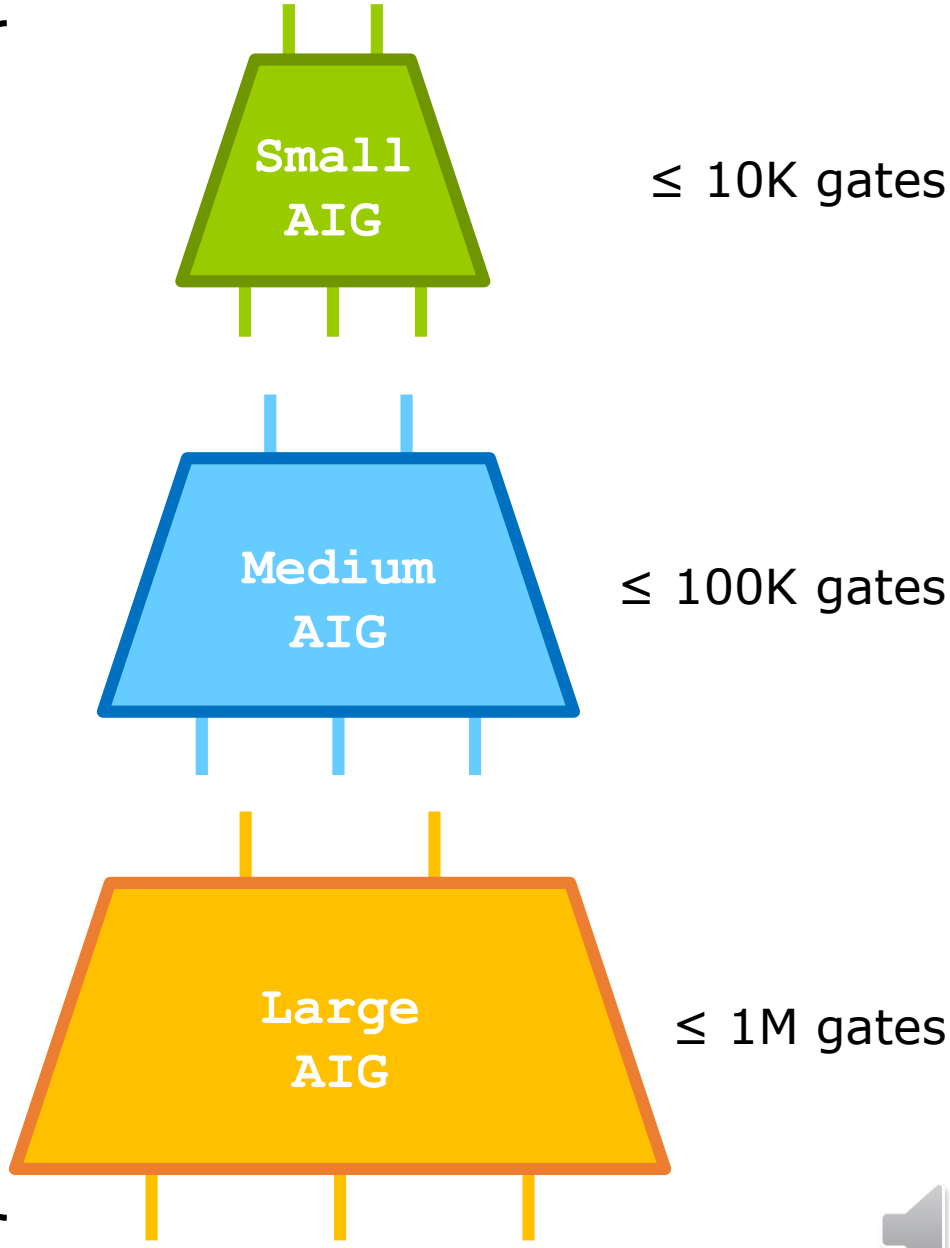
Problem Description



CIFAR-10 dataset

learn



Problem Description

- Target function to be learned:

height width #channels #bits per pixel

$$32 \times 32 \times 3 \times 8$$

$$f\colon \{0,1\}^{24{,}576} \rightarrow \{0,1\}^{10}$$

$\mathbf{24,576}$ is larger than the size limit $\mathbf{10,000}$ of small AIGs!

Image Preprocessing

- Down-sampling

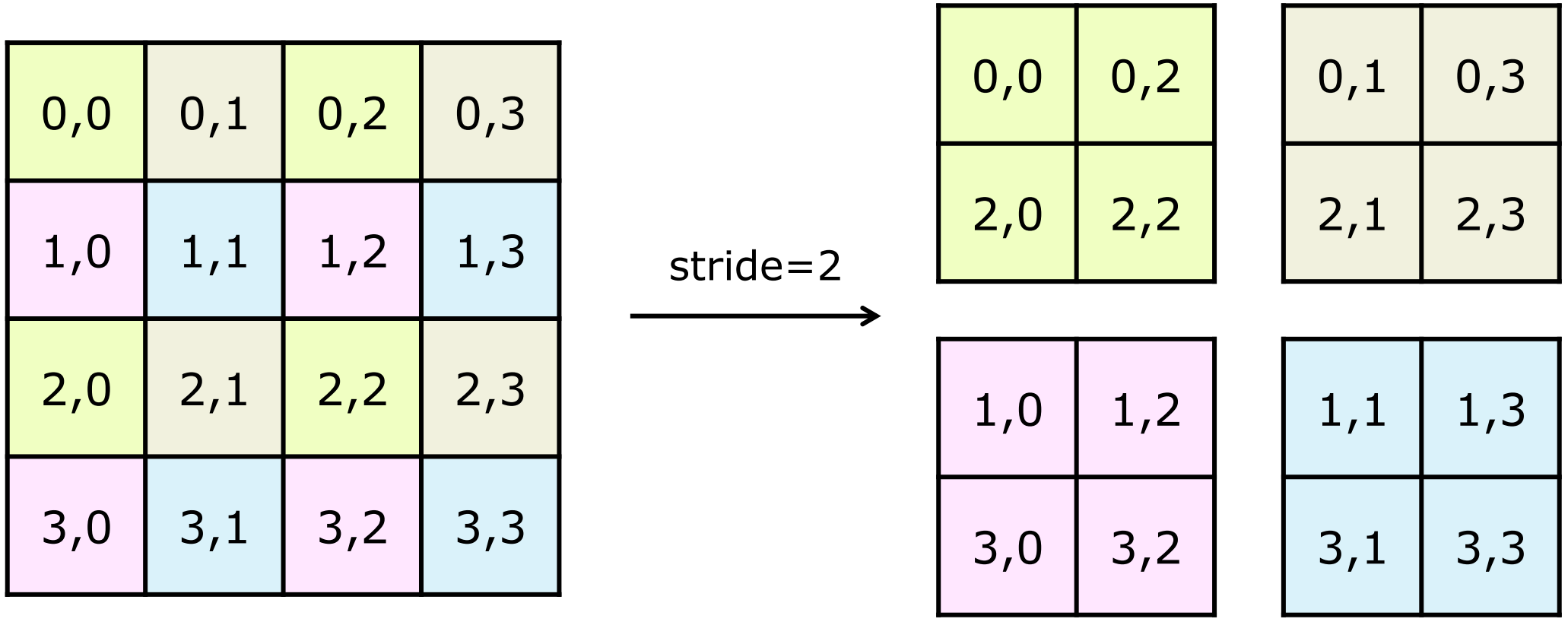


Image Preprocessing

- Bit truncation of each pixel

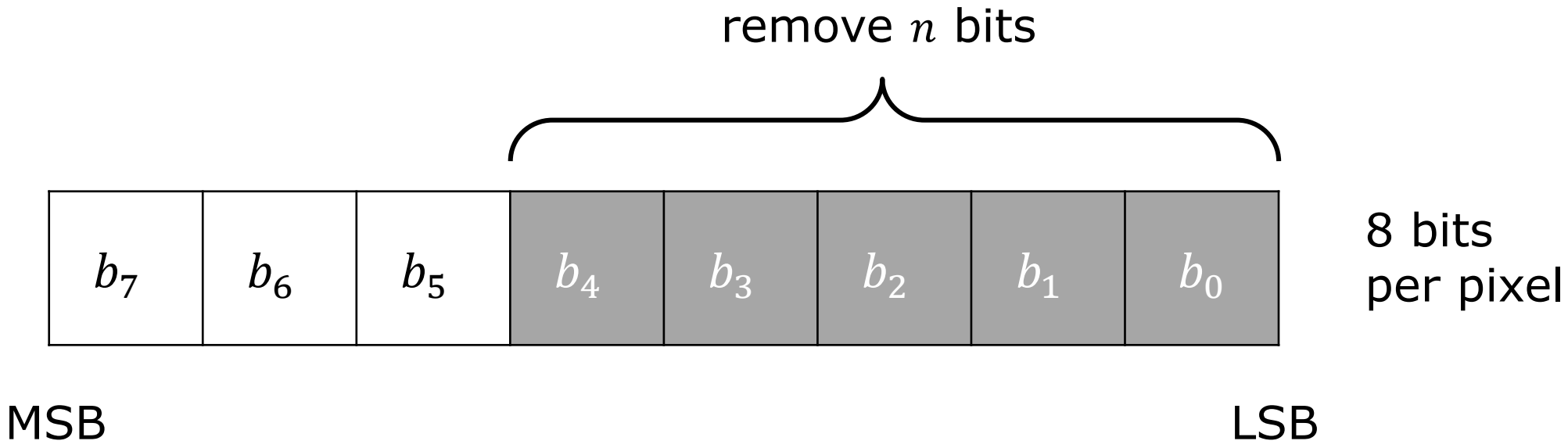


Image Preprocessing

- Augmentation: flip, shift, scale, rotate…

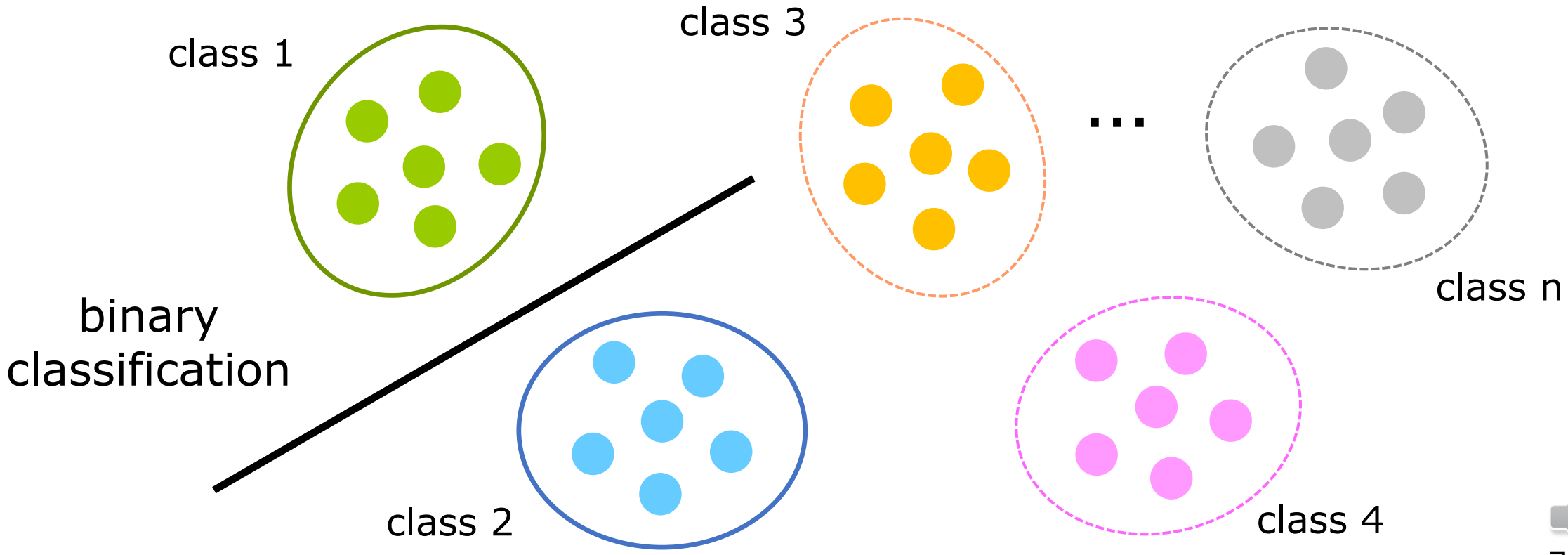
0,0	0,1	0,2	0,3
1,0	1,1	1,2	1,3
2,0	2,1	2,2	2,3
3,0	3,1	3,2	3,3

horizontal flip →

0,3	0,2	0,1	0,0
1,3	1,2	1,1	1,0
2,3	2,2	2,1	2,0
3,3	3,2	3,1	3,0

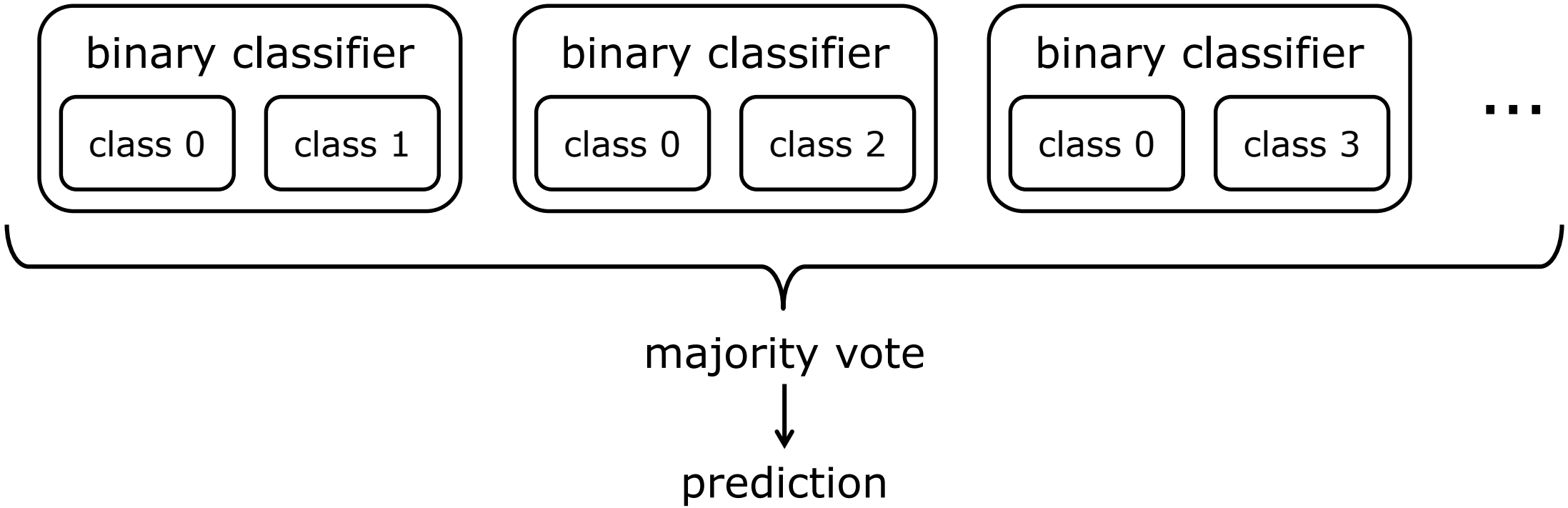
Learning Small Circuits

- Construct multi-class classifier using **one-against-one (OAO)** approach with binary classifiers.



Learning Small Circuits

- For CIFAR-10 dataset, there are $C(10,2) = 45$ binary classifiers in total.



Learning Small Circuits

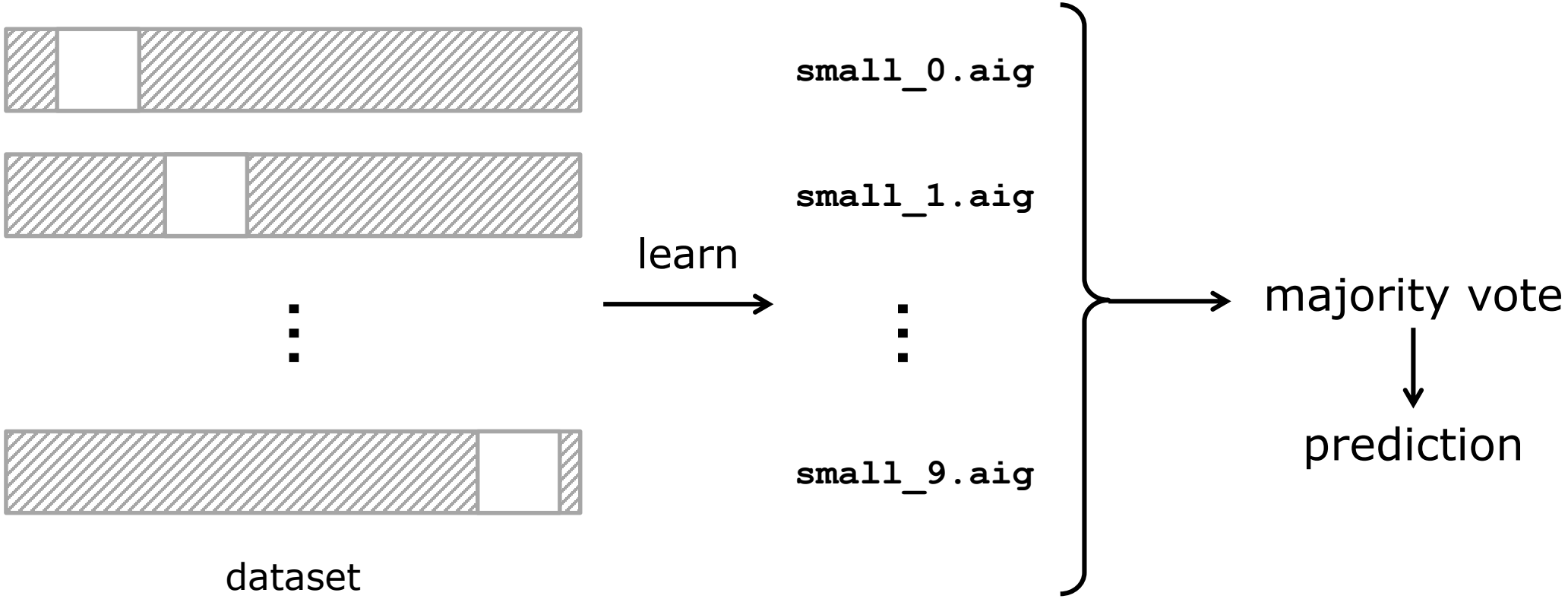
- Type of binary classifier:
  - decision tree classifier from scikit-learn [1]

- To restrict size and avoid overfitting:
  - maximum tree depth `(max_depth)`
  - cost complexity pruning `(ccp_alpha)`

[1] Pedregosa et al., 2011.

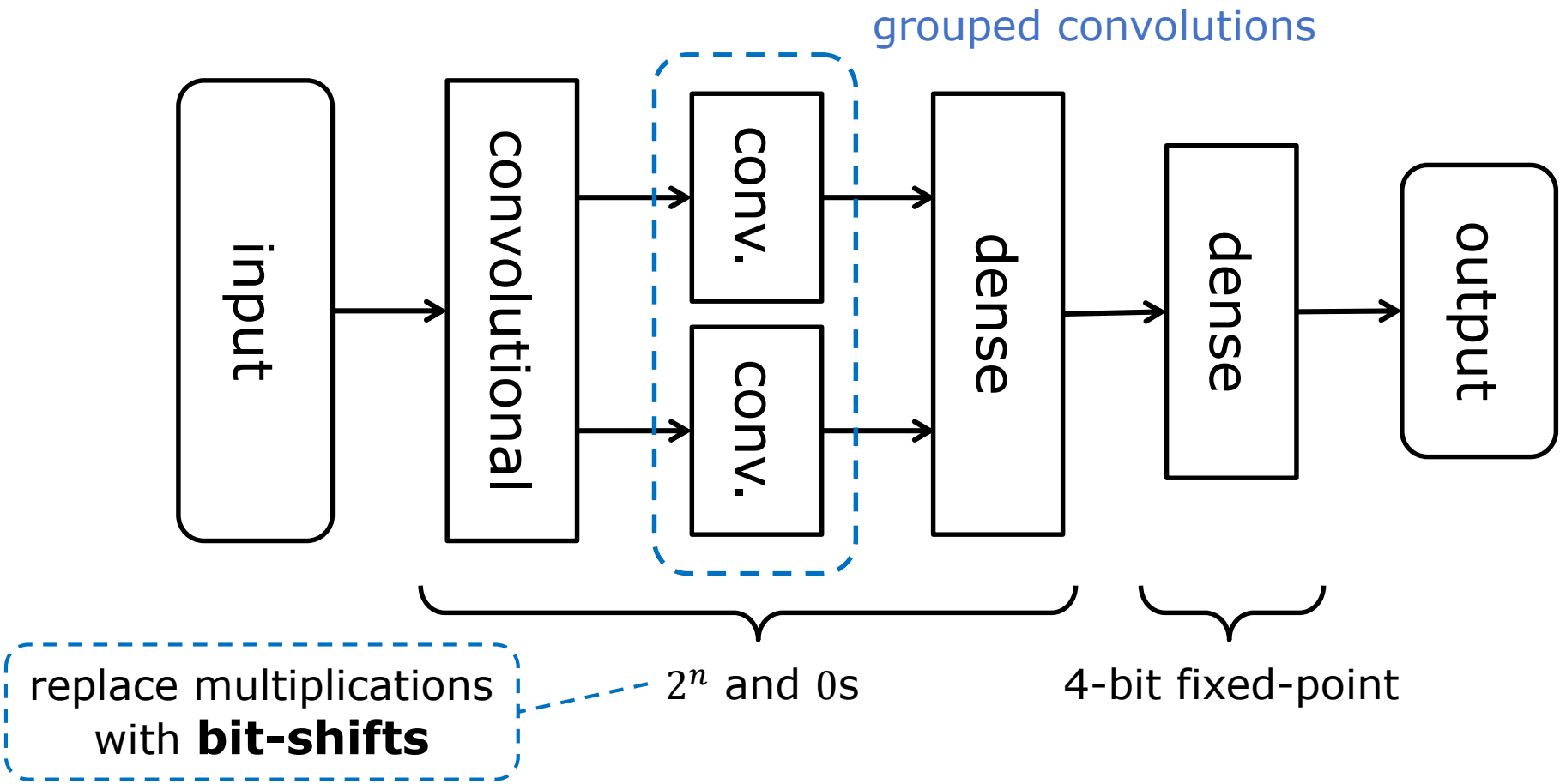
Learning Medium Circuits

- Ensemble of 10 small classifiers trained with different portions of the dataset.



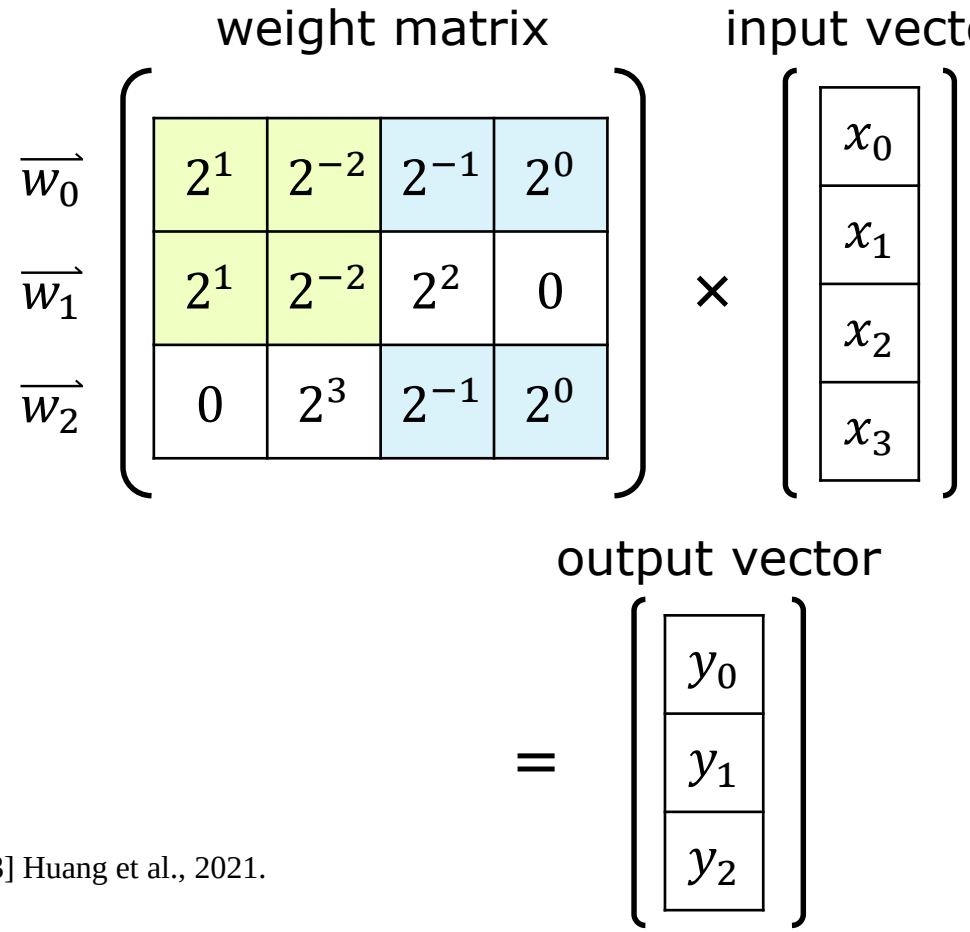
Learning Large Circuits

- Shallow CNN with grouped convolutions and quantized weights.

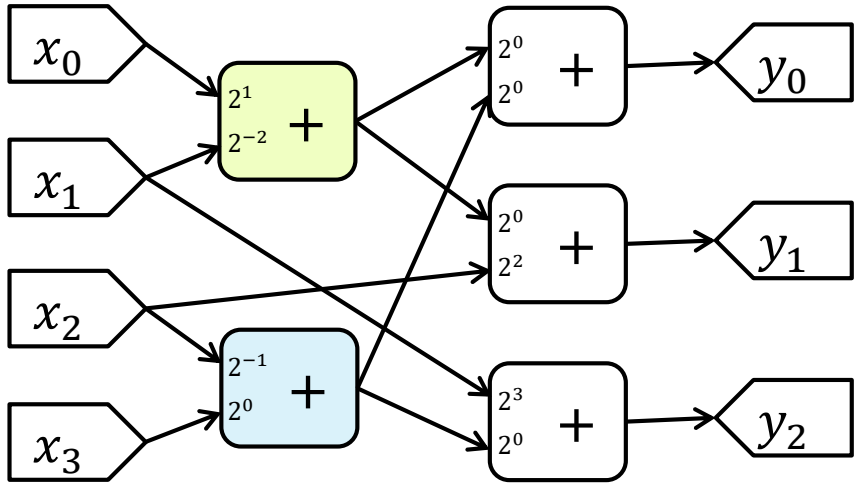


Learning Large Circuits

- CNN synthesized with sub-adder sharing [3].



w/ sharing



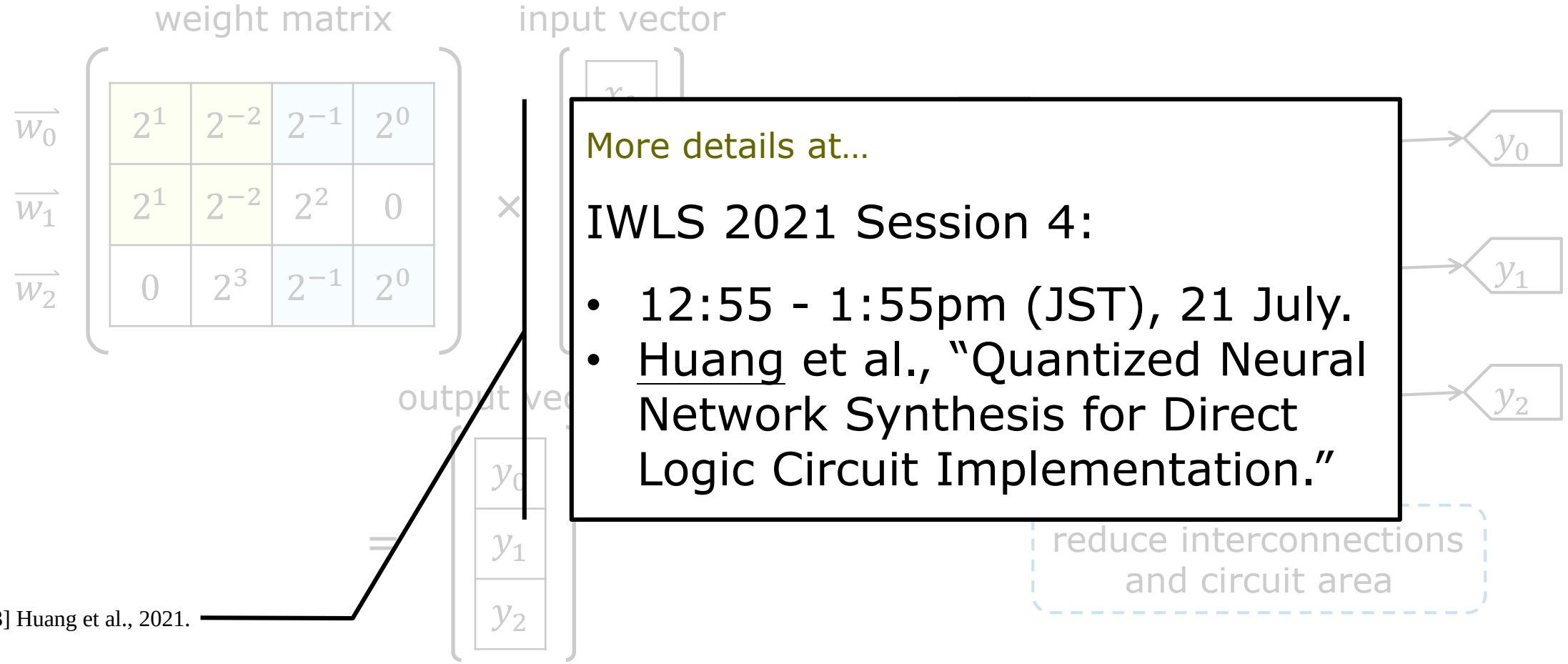
reduce interconnections and circuit area

(30% lesser AIG-nodes)

[3] Huang et al., 2021.

Learning Large Circuits

- CNN synthesized with sub-adder sharing [3].



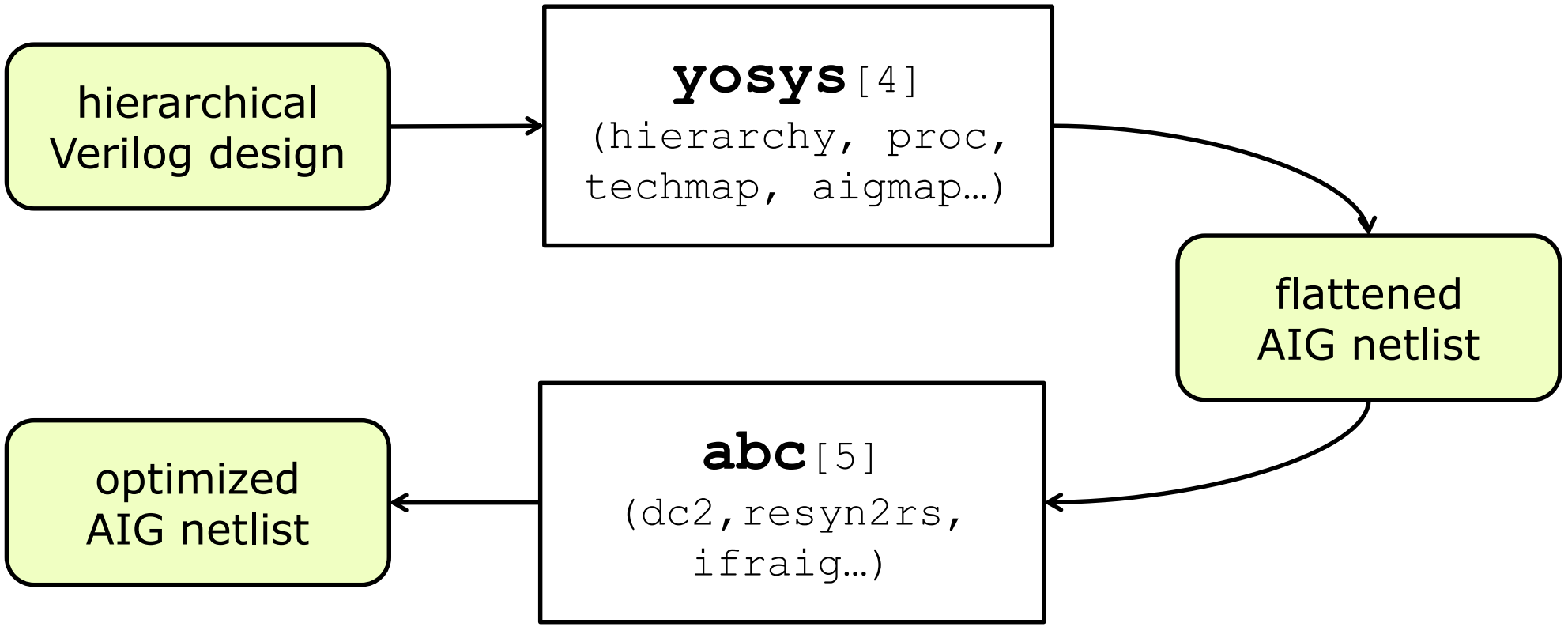
More details at…

IWLS 2021 Session 4:

- 12:55 - 1:55pm (JST), 21 July.
- Huang et al., "Quantized Neural Network Synthesis for Direct Logic Circuit Implementation."

[3] Huang et al., 2021.

Logic Synthesis



[4] Wolf et al., 2013. [5] Brayton et al., 2010.

Our Results

- Submitted version

	small	medium	large
size (#gates)	9,697	97,350	995,247
training acc.	44.96%	56.77%	59.33%
testing acc.	39.31%	44.69%	54.68%

Our Results

- Newer version (after fine-tuning and bug fixing)

	small	medium	large
size (#gates)	9,697 → 9,273	97,350 → 99,873	995,247 → 967,173
training acc.	44.96% → 43.89%	56.77% → 54.99%	59.33% → 59.18
testing acc.	39.31% → 39.51%	44.69% → 45.44%	54.68% → 56.34

smaller gap (less overfitting)

higher

Conclusions

- Our methods and results can be summarized as follows.

	small	**medium**	**large**
model structure	decision tree	decision tree	neural network
size (#gates)	9,273	99,873	967,173
testing acc.	39.51%	45.44%	56.34%

- The source code will be made public at https://github.com/NTU-ALComLab/IWLS2021.

THE END