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Integrated Circuit Mask-GAN

Speaker: Tee Yee Yang

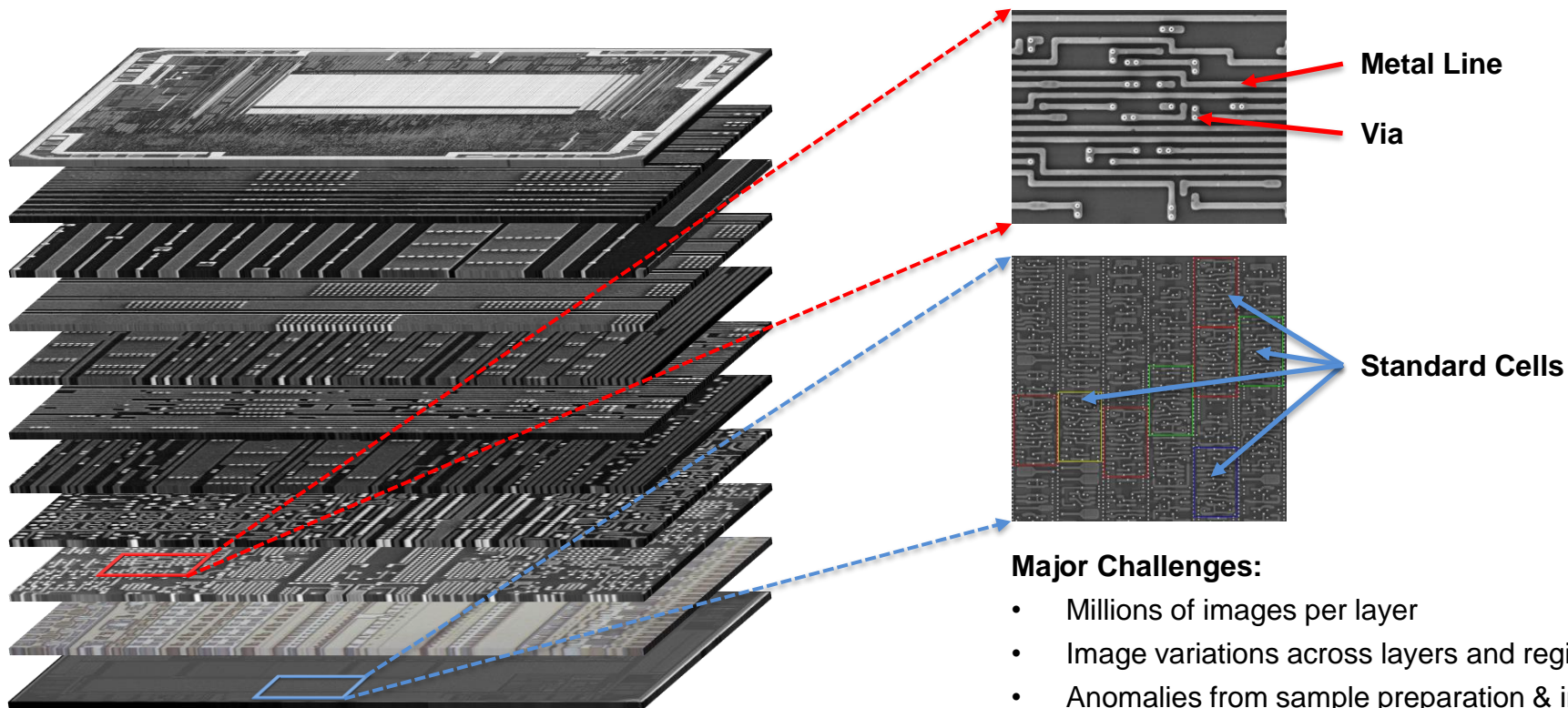
For HARRIS, Mar 2024



Outline

- **Background: Microscopic IC Image Analysis**
- **Deep Learning based IC Image Analysis Framework**
- **Integrated Circuit Mask-GAN (ICMG)**
 - Background and Intuition
 - Methodology
 - Experimental Results
- **Conclusion**

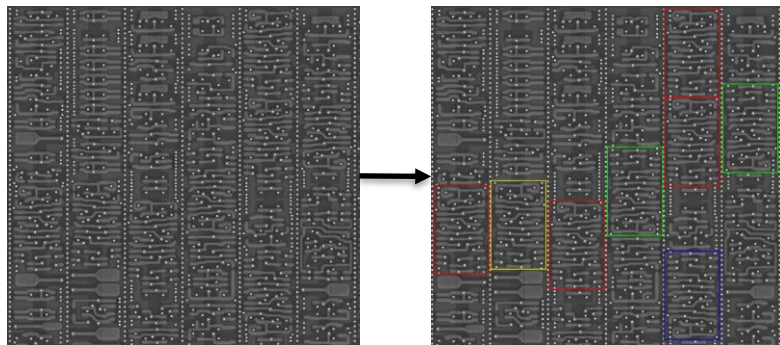
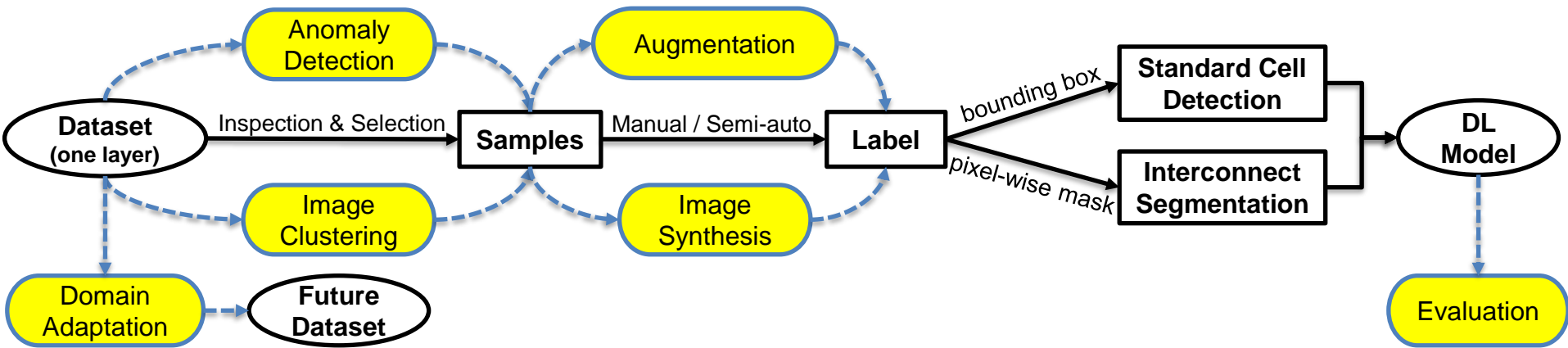
Introduction to Microscopic IC Image Analysis



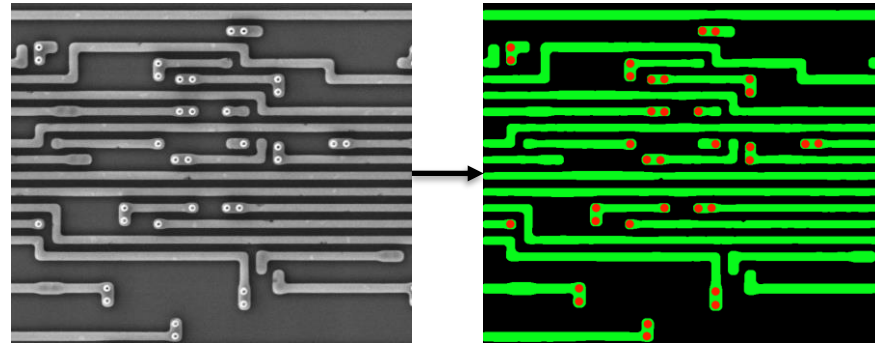
Major Challenges:

- Millions of images per layer
- Image variations across layers and regions
- Anomalies from sample preparation & imaging
- Small feature size / narrow gap between features

Deep Learning (DL)-based Image Analysis Framework

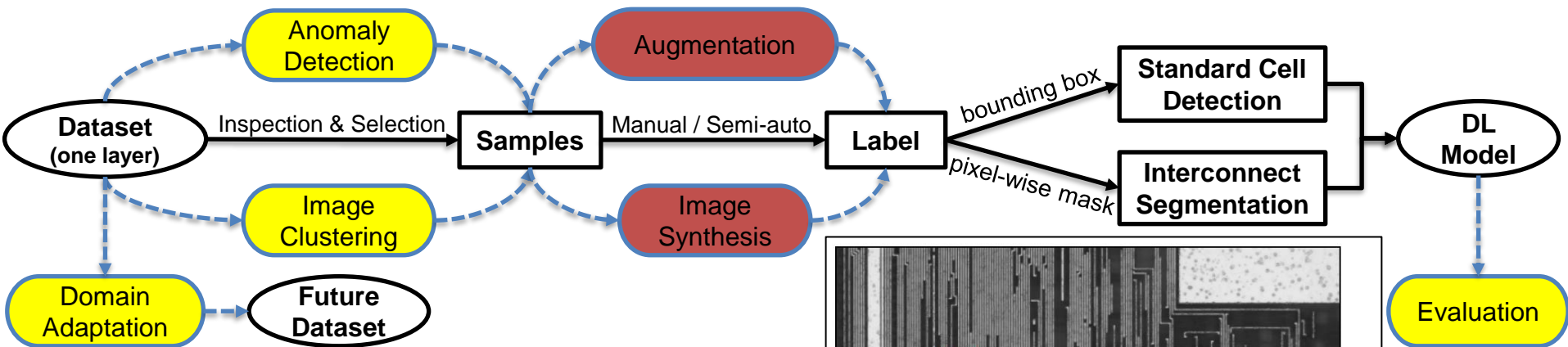


Standard Cell Detection in Poly Layer



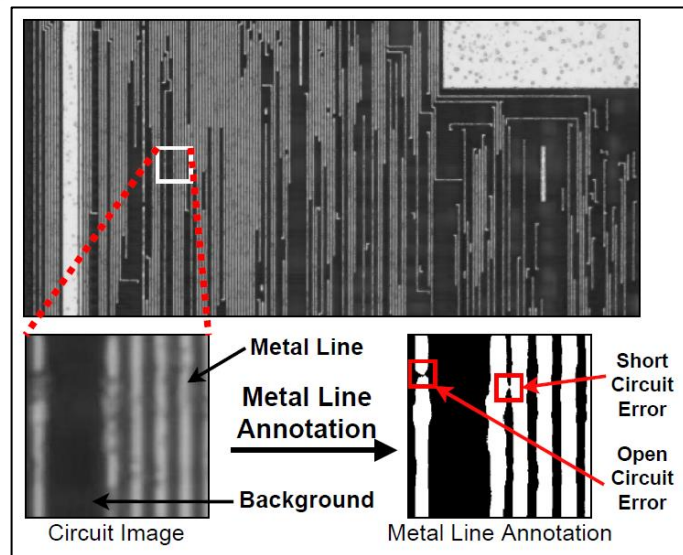
Interconnect Segmentation in Metal Layers

Deep Learning (DL)-based Image Analysis Framework



Next, we present a GAN-based image synthesis method with 2 goals:

- Reduce the manual effort for data labelling
- Improve segmentation performance in terms of circuit connection errors

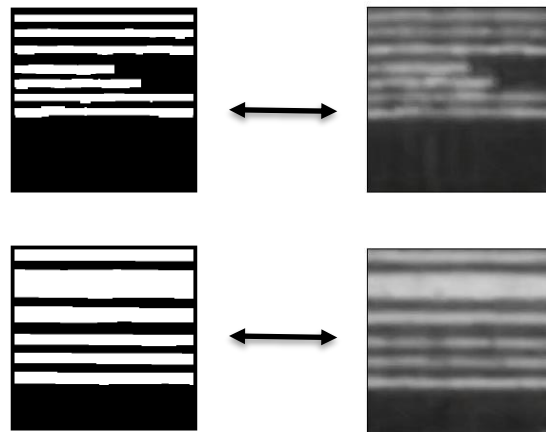


Integrated Circuit Mask-GAN: Background and Intuition

Image to Image Translation



Why not do this for IC images?



ICMG: Methodology

Conventional Fully supervised learning

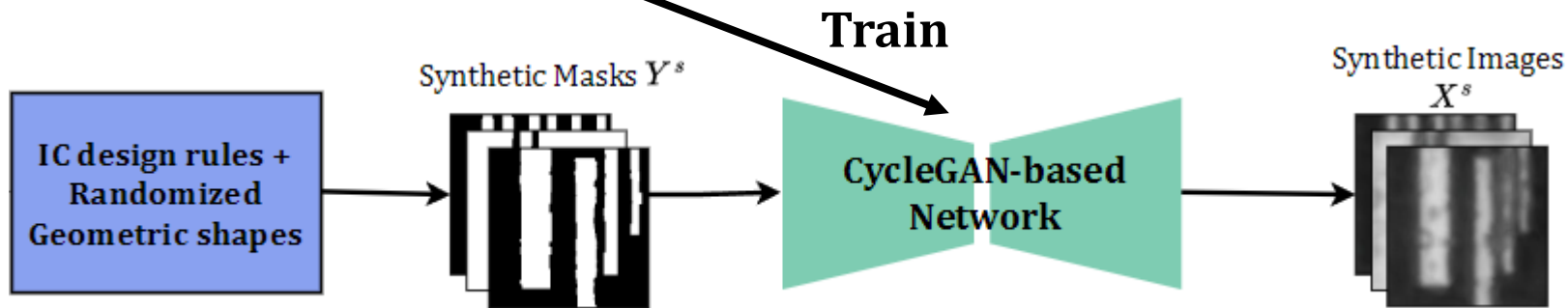
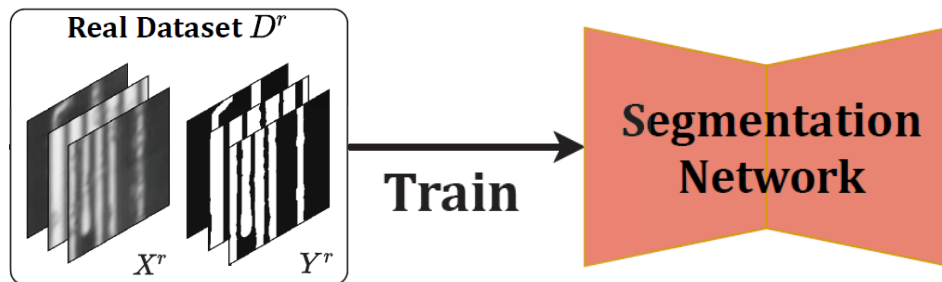
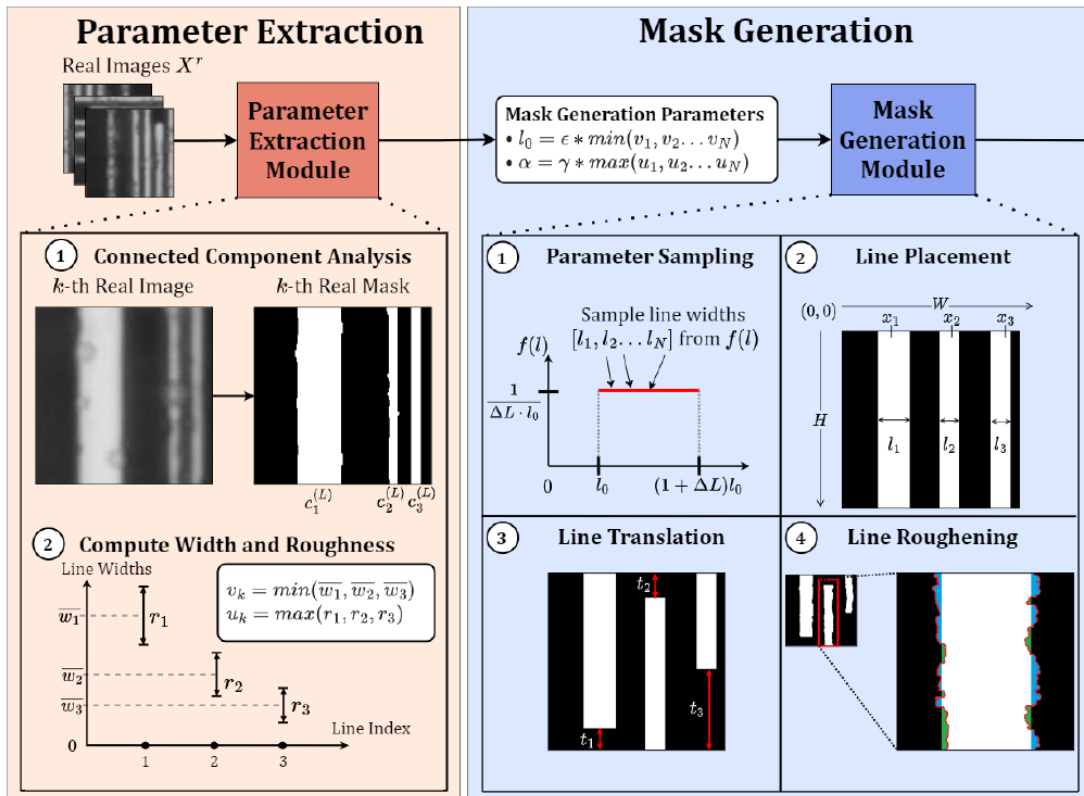


Image Synthesis

ICMG: Methodology



ICMG: Experimental Results

- Model evaluation is performed on images from an entire metal layer from a microcontroller device.
- There are 230,400 images at (256x256) resolution in the evaluation set.

Method	Number of Labeled Images	Number of Unlabeled Images	Number of Synthetic Images	Pixel-wise Accuracy	IoU	Inference Time per Image (ms)	Circuit Connection Errors [†]
Lin et al. [1]	3,600	—	—	0.9839	0.9438	5.256	304
Hung et al. [2]	3,600	28,800	—	0.9715	0.9279	6.226	204
French et al. [3]	3,600	28,800	—	0.9793	0.9320	7.571	424
Abhishek et al. [4]	3,600	—	3,600	0.9744	0.9312	5.136	286
Proposed ICMG	3,600	—	28,800	0.9816	0.9373	5.549	67
Proposed ICMG (reduced data)	900	—	7,200	0.9802	0.9313	5.373	89
Proposed ICMG (reduced data)	360	—	2,800	0.9814	0.9364	5.352	113

[†] Out of 8,666 total circuit connections.

[1] T. Lin, Y. Shi, N. Shu, D. Cheng, X. Hong, J. Song, and B. H. Gwee, "Deep learning-based image analysis framework for hardware assurance of digital integrated circuits," *Microelectronics Reliability* 2021.

[2] W. C. Hung, Y. H. Tsai, Y. T. Liou, Y.-Y. Lin, and M. H. Yang, "Adversarial learning for semi-supervised semantic segmentation," in *British Machine Vision Conference*, 2018.

[3] G. French, S. Laine, T. Aila, M. Mackiewicz, and G. Finlayson, "Semi-supervised semantic segmentation needs strong, varied perturbations," in *British Machine Vision Conference*, no. 31, 2020.

[4] K. Abhishek and G. Hamarneh, "Mask2lesion: Maskconstrained adversarial skin lesion image synthesis," in *International Workshop on Simulation and Synthesis in Medical Imaging*. Springer, 2019, pp. 71–80.

Conclusion

- A deep learning-based framework for IC image analysis has been presented. Deep learning models can be effectively applied to retrieve the standard cells and interconnects in IC image analysis, concerning a wide variety of tasks and solutions.
- A major limitation of supervised learning models is their requirements on considerable amount of labelled data. Unsupervised or semi-supervised analysis are promising techniques to address this.
- Integrated Circuit Mask-GAN, a targeted data augmentation technique, has been presented for and demonstrated significant improvements in the circuit annotation task.

Thank You!

Questions?

Contact Me

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