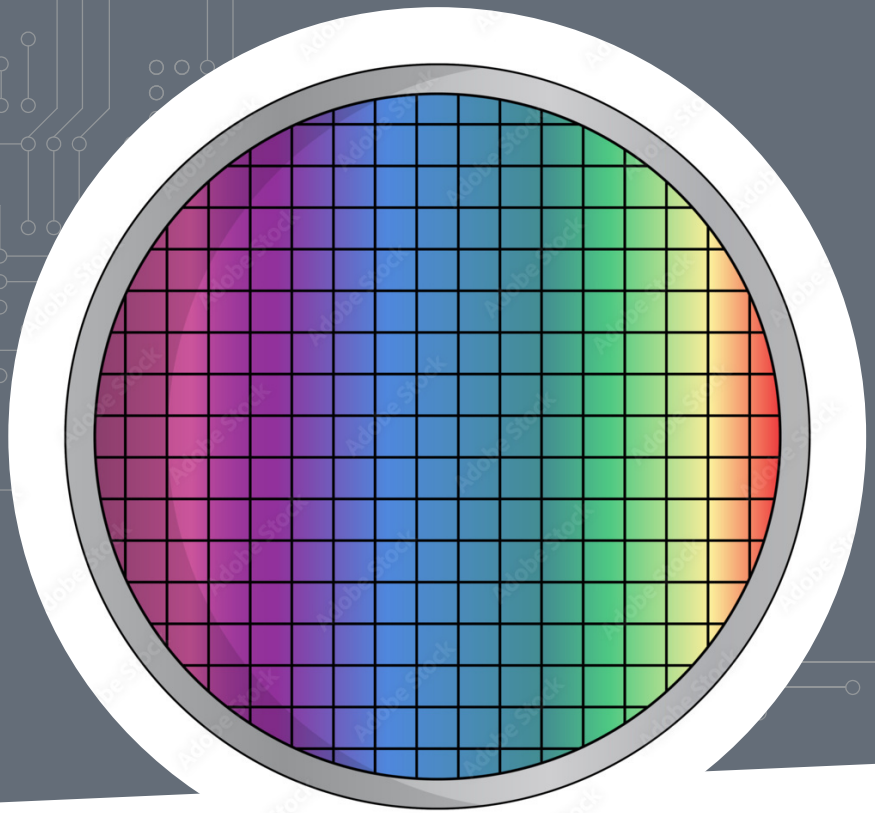


Deep Learning

WaferMap Defect Pattern Recognition using improved DCN

第七組 |

RE6121045 侯登耀 數據所　P76121372 陳冠宇 資訊所

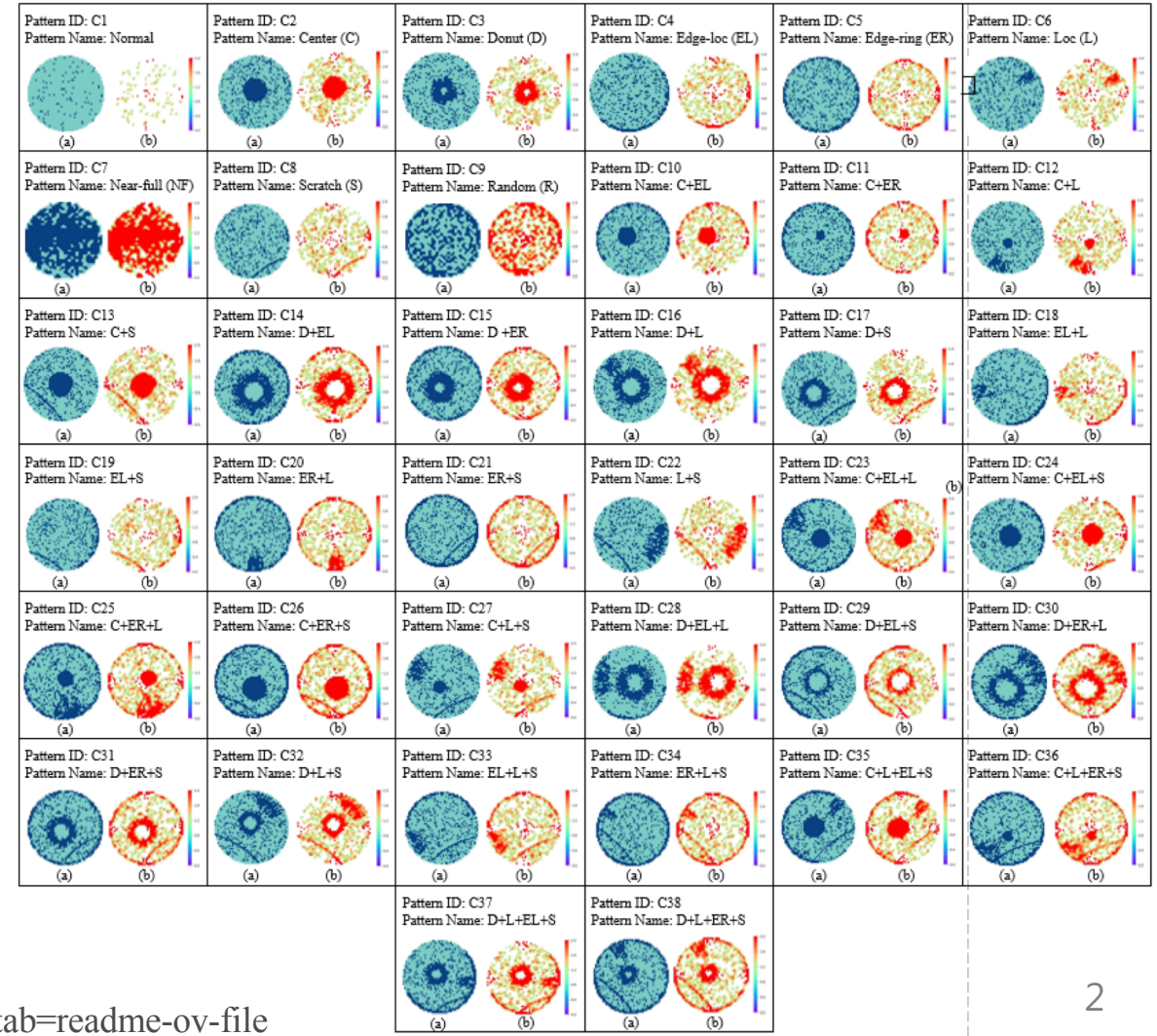
RE6125015 劉仁忠 數據所　P76124825 林柏志 資訊所

WaferMap Defect Pattern Recognition using improved DCN

Dataset:

MixedWM38

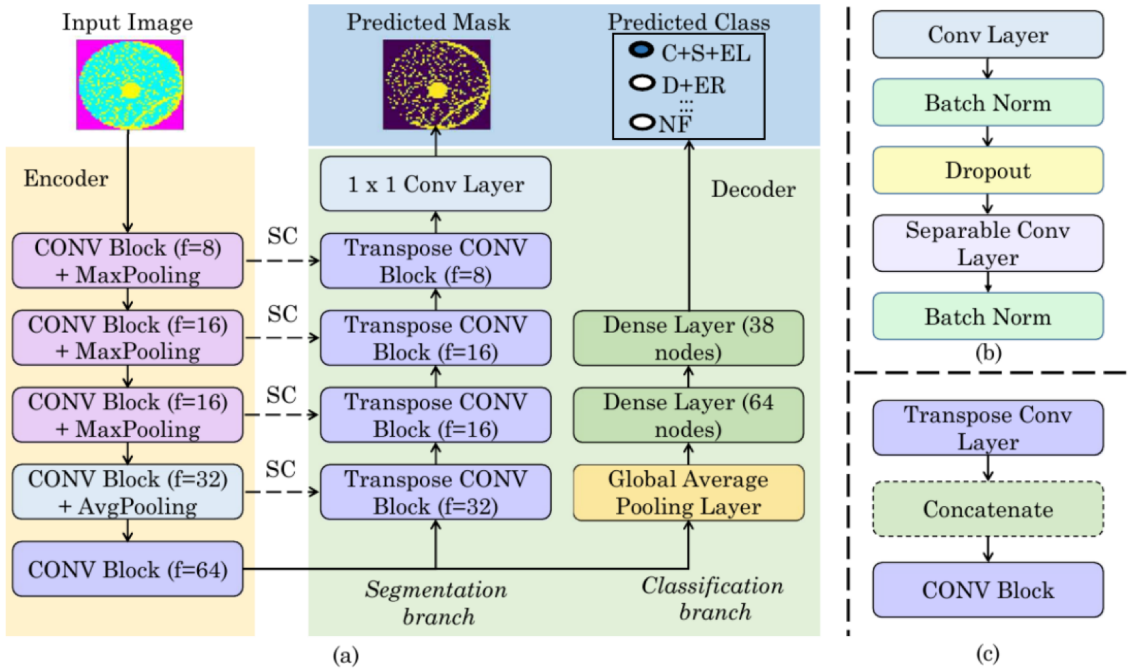
- 38015 wafer maps
- 38 defect patterns



Dataset Source:
https://github.com/Junliangwangdhu/WaferMap/tree/master?tab=readme-ov-file

SOTA Model - WaferSegClassNet

Nag et al. 2022. WaferSegClassNet



Acc: 98.20%
Epochs: 50 (as accuracy didn't increase afterwards)
Running Time: +- 150 minutes
Advantage: High Accuracy
Disadvantage: Computational time

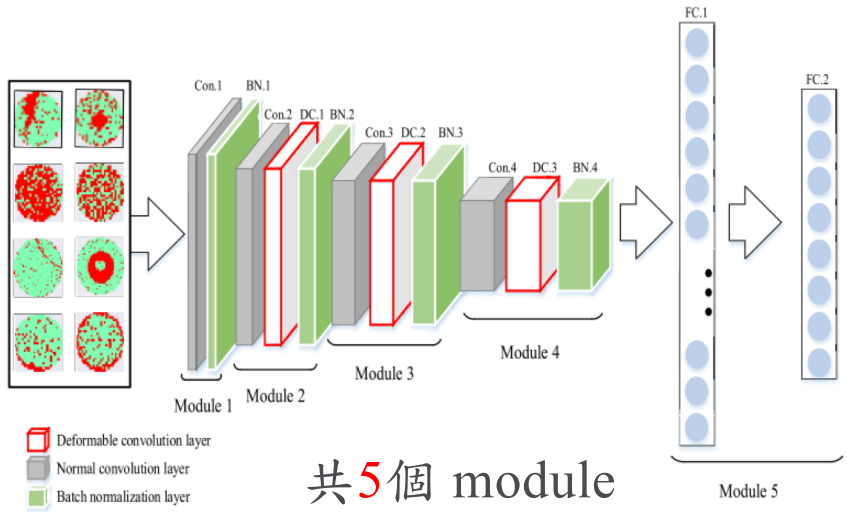
Encoder stage

dual purpose Decoder stage

(b) CONV Block,
(c) Transpose CONV block

Our Baseline Model - DCN

Wang et al. 2020. Deformable Convolutional Networks for Efficient Mixed-Type Wafer Defect Pattern Recognition



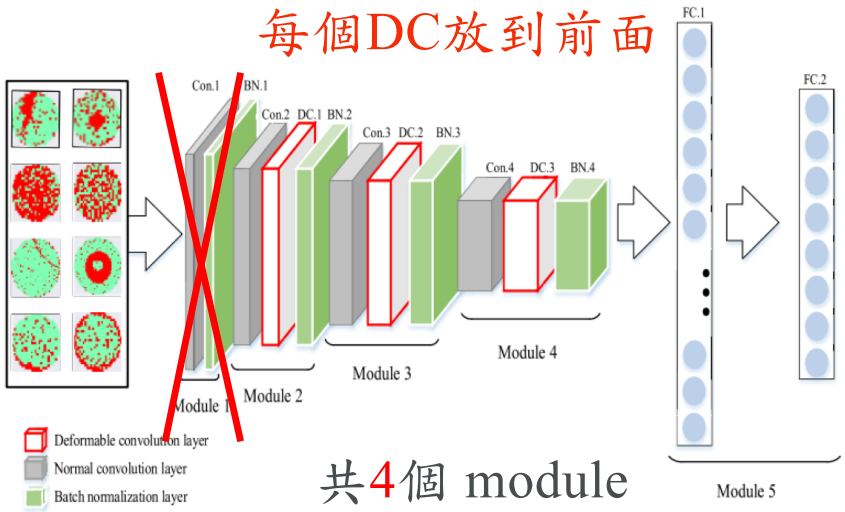
共5個 module

Loss Function: Binary Cross-entropy

Reproduce using Pytorch
Acc: 94.4%
Epochs: 10
Time: +- 4 minutes

Our modified model – Changes in network layer

每個DC放到前面



共4個 module

Loss Function: ŷ MSE > 0.5 = 1, else 0

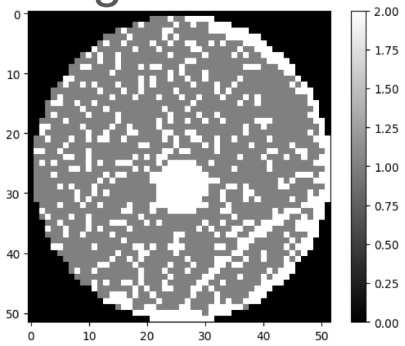
Reproduce using Pytorch
Acc: 96.4%
Epochs: 10
Time: +- 4 minutes

Our Previous Model Comparisons

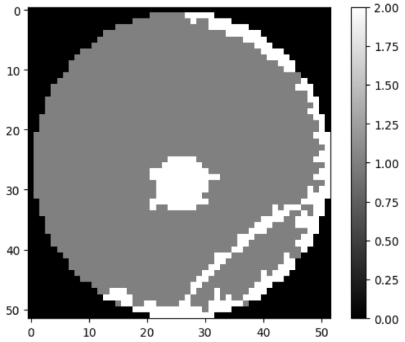
Model Version	Model Contents	Activation function	Epoch	Validation Accuracy
V1	Modify the model from Wang et al. 2020.	relu	10	96.60 %
V2	Modify Abnormal Values + V1	gelu	30	97.78 %
V3	Use CCA Denoised images + V2	gelu	30	94.00 %
V4	data augmentation (vertical flip & horizontal flip) + V2	gelu	30	97.92 %
V5	V1 + V3 (no data augmentation)	gelu	30	97.65 %

Combined Model (V5)

Original Data



After CCA



DCN without last two layers

DCN without last two layers

dim: 128

dim: 128

Concat two embeddings

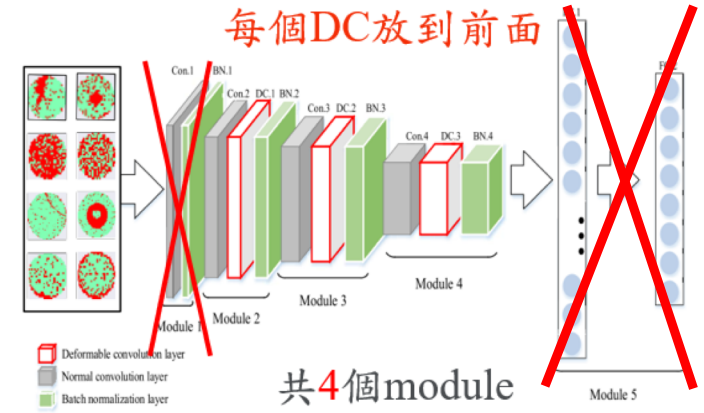
dim: 256

Linear

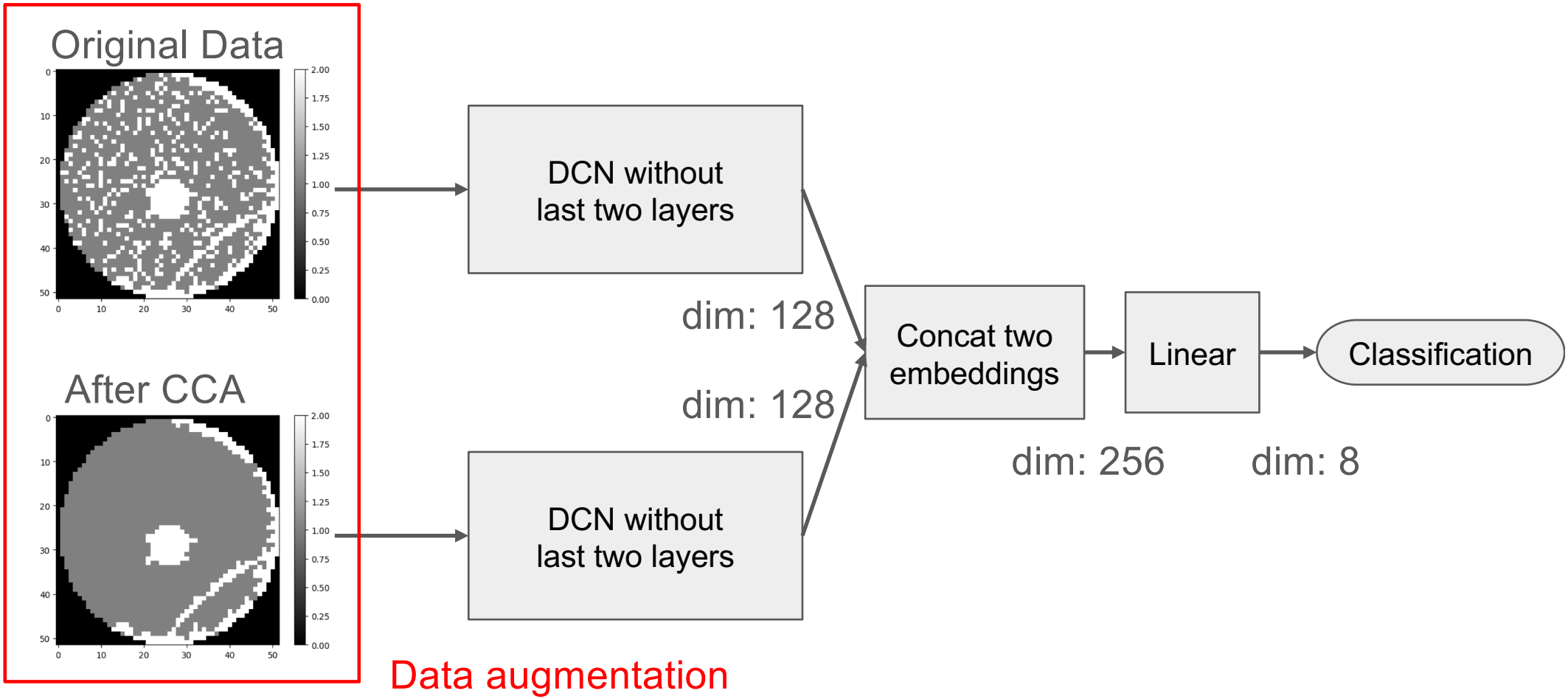
dim: 8

Classification

Our model – Changes in network layer



Combined Model (V6)



Explore Other Denoising Methods

CCA > 10

[[1. 1. 1.]
[1. 1. 1.]
[1. 1. 1.]]
Threshold > 3

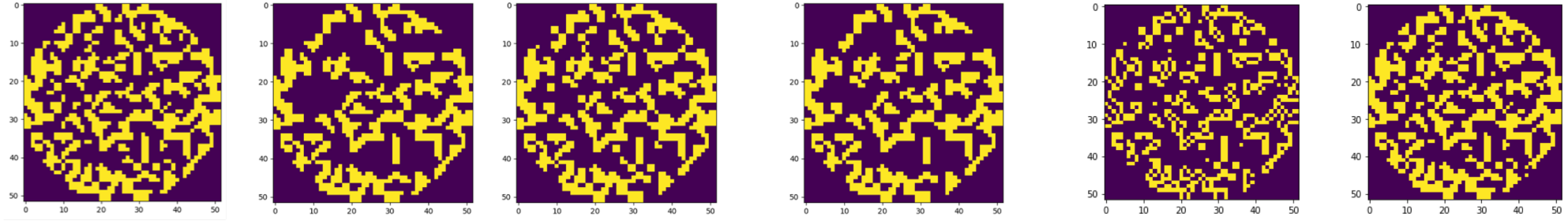
Threshold > 3
CCA > 5

Laplace

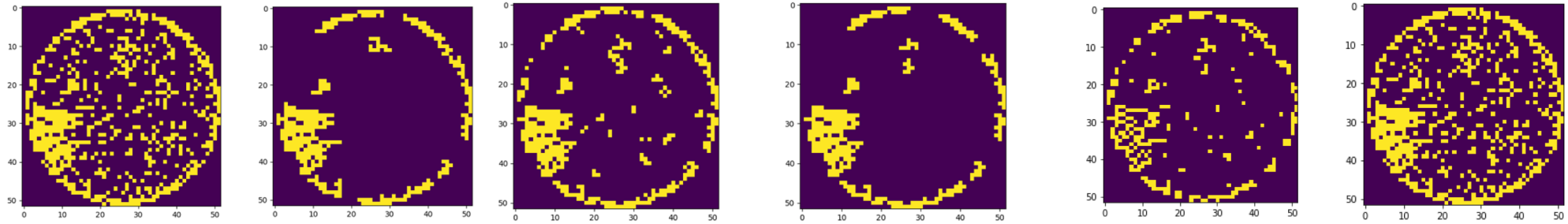
Threshold > 0.5

Baseline(V2)	CCA(V3)	Filter	Filter + CCA	Edge	C_mean
97.78	94.00	96.66	95.34	95.55	95.17

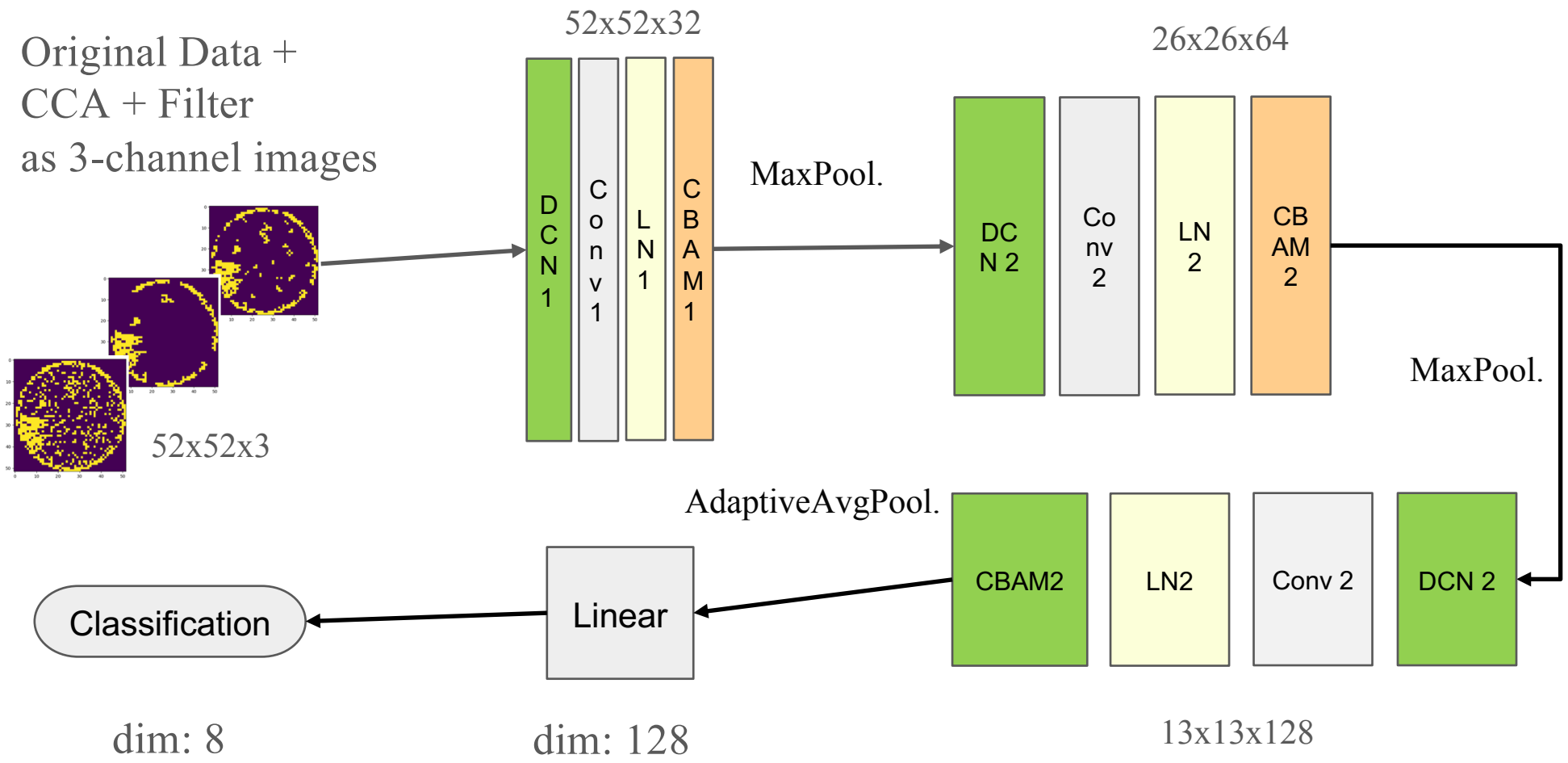
RANDOM



EDGERING



Channel-Combined Model (V7)



Final Model Comparisons

Model	Validation Accuracy	Params	FLOPS
WSCN	98.20	90.00K	0.2M
Model V5	97.65	437.78K	1.817G
Model V6	98.17	437.77K	14.536G
Model V7	98.15	543.91K	2.740G

Classwise Accuracy Results

Class	Accuracy				Precision				Recall			
	WSCN	Model V5	Model V6	Model V7	WSCN	Model V5	Model V6	Model V7	WSCN	Model V5	Model V6	Model V7
1	100	100	100	100	100	98	99	99	100	100	100	100
2	100	100	100	99.10	99	99	99	98	100	100	100	99
3	100	99.45	100	100	96	98	97	97	100	99	100	100
4	97	96.52	99.5	97.98	98	99	99	99	98	97	99	98
5	99	99.11	98.5	98.79	97	97	98	98	99	99	98	99
6	99	98.96	99	97.93	99	100	98	99	99	99	99	98
7	100	85.71	100	100	92	100	100	100	100	89	100	100
8	99	98.26	99.5	97.13	97	97	99	98	100	98	99	97
9	98	100	99.42	98.25	100	98	100	100	98	100	99	96

Class	Accuracy				Precision				Recall			
	WSCN	Model V5	Model V6	Model V7	WSCN	Model V5	Model V6	Model V7	WSCN	Model V5	Model V6	Model V7
10	98	98.08	98.5	97.66	98	97	98	99	99	98	98	98
11	100	100	99.5	100	99	98	99	98	100	100	99	100
12	99	98.94	99	97.88	99	97	97	97	100	99	99	98
13	99	100	99	98.51	98	97	98	99	100	100	99	99
14	94	97.52	99.5	97.21	100	99	98	99	95	98	99	97
15	99	99.5	97.5	100	98	99	97	97	99	100	97	100
16	95	98.85	99	96.55	100	97	98	98	95	99	99	97
17	100	98.63	98	100	96	98	98	98	100	99	98	100
18	99	98.93	98.5	98.97	99	96	97	96	100	99	98	99
19	97	96.74	99.5	98.97	99	99	100	98	98	97	99	99
20	96	96.61	98	99.53	99	98	98	99	96	96	98	100
21	100	99	100	99.56	98	97	99	99	100	99	100	100
22	97	97.98	97	96.86	99	98	98	95	97	98	97	97

Class	Accuracy				Precision				Recall			
	WSCN	Model V5	Model V6	Model V7	WSCN	Model V5	Model V6	Model V7	WSCN	Model V5	Model V6	Model V7
23	97	93.88	95	97.51	97	98	96	98	97	94	95	98
24	99	98.56	99	99.48	99	99	99	99	99	99	99	99
25	97	97.45	96.98	98.48	98	96	97	97	98	97	96	98
26	100	99.52	99.5	100	99	97	98	98	100	100	99	100
27	97	95.50	96	97.01	99	99	99	97	97	95	96	97
28	97	99.09	99	98.54	95	98	99	97	97	99	99	99
29	96	98.99	94.5	97.60	97	98	96	98	97	99	94	98
30	100	100	97.5	99.48	94	100	98	100	100	100	97	99
31	98	99.07	98	98.44	98	97	96	97	99	99	98	98
32	97	97	97	96.19	98	98	98	99	97	97	97	96
33	96	96.46	95.5	94.37	100	99	99	99	96	96	95	94
34	97	97.19	97	98.99	97	98	99	98	98	97	97	99

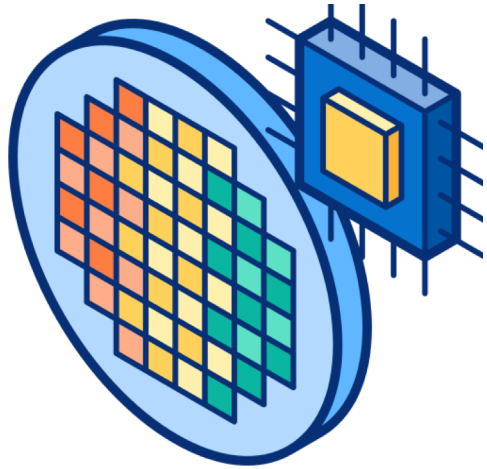
Class	Accuracy				Precision				Recall			
	WSCN	Model V5	Model V6	Model V7	WSCN	Model V5	Model V6	Model V7	WSCN	Model V5	Model V6	Model V7
35	94	93.75	96	95.05	100	97	98	98	95	94	96	95
36	97	95.67	98	96.79	98	98	98	99	98	96	98	97
37	95	93.58	94.5	95.81	99	99	100	99	95	94	94	96
38	95	97.12	99	97.95	99	98	99	99	95	97	99	98

Class	Accuracy				Precision				Recall			
	WSCN	Model V5	Model V6	Model V7	WSCN	Model V5	Model V6	Model V7	WSCN	Model V5	Model V6	Model V7
AVG (1 Defect)	99.00	97.55	99.54	98.64	97.25	98.44	98.78	99.33	99.33	97.89	99.33	98.44
AVG (2 Defect)	97.92	98.52	98.69	98.61	98.62	97.69	98.07	97.53	98.38	98.61	98.46	98.69
AVG (3 Defect)	97.58	97.73	97.08	97.41	97.58	98.08	97.83	97.25	97.92	97.67	96.83	97.25
AVG (4 Defect)	95.25	95.03	96.88	94.39	99.00	98	98.75	98.25	95.75	95.25	96.75	94
AVG (All Defect)	98.20	97.65	98.17	98.15	98.08	98.03	98.24	98.21	98.18	97.79	97.97	98.21

Conclusion and Future Goals

- In this project, we modified the original DCN model and developed several useful models for the wafer map defect pattern classification problem.
- Although our models do not surpass the SOTA model in overall accuracy, they outperform in 21 out of 38 classes.
- We can focus on explainable AI, such as CAM-based models, in the future.

References



- MixedWM38 Dataset
  - https://github.com/Junliangwangdhu/WaferMap
  - https://www.kaggle.com/datasets/co1d7era/mixedtype-wafer-defect-datasets
- Deformable Convolutional Networks for Efficient Mixed-Type Wafer Defect Pattern Recognition
  - https://ieeexplore.ieee.org/document/9184890
- WaferSegClassNet -- A Light-weight Network for Classification and Segmentation of Semiconductor Wafer Defects
  - https://arxiv.org/abs/2207.00960
- WM-811K
  - https://www.kaggle.com/datasets/qingyi/wm811k-wafer-map/data
- DCNv2
  - https://arxiv.org/abs/2008.13535v2

Thanks for your attention.