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Tango AI

Techniques for Wafer Map Classification

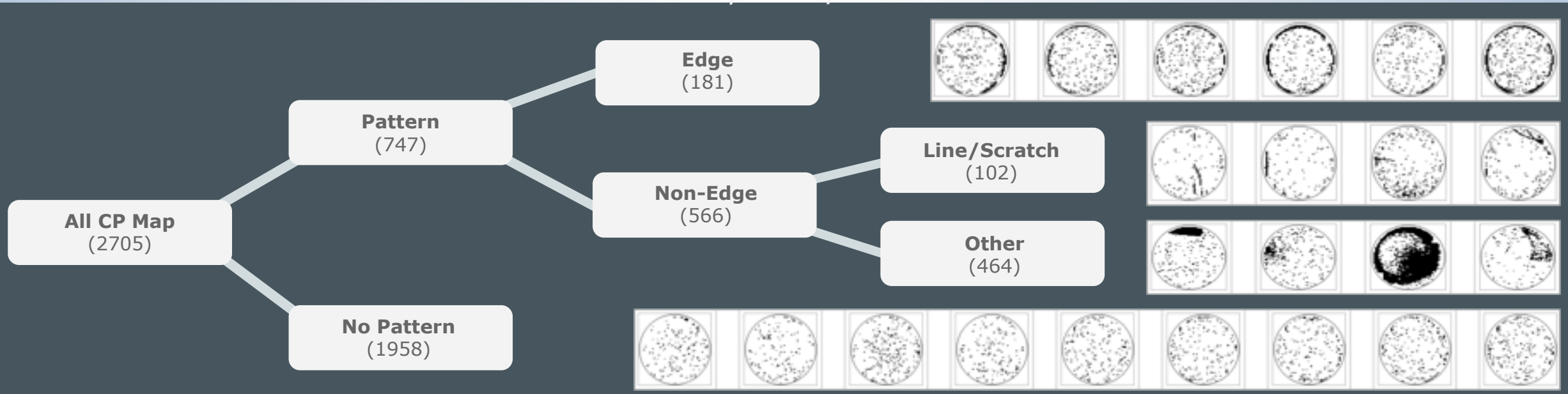
Take Edge and Line/Scratch Pattern as Example

Tango-AI

Background

- When the bin map exhibits specific patterns, it is usually a clue that equipment problems or process variations have occurred.
- Visual inspection by engineers:
  - Potential misjudgment due to human fatigue.
  - The process can incur significant personnel costs

Developed Methods Application



- Step 1: Pattern Map Detection using DBSCAN Algorithm
  - ✓ takes about 8 mins
- Step 2: Edge Pattern Classification by pre-constructed machine learning (CNN) Model
  - ✓ takes about 25 secs
- Step 3: Line Pattern Detection using Hough Transform Algorithm
  - ✓ takes about 2 secs

Algorithm Output (as xlsx File)

Page
1.

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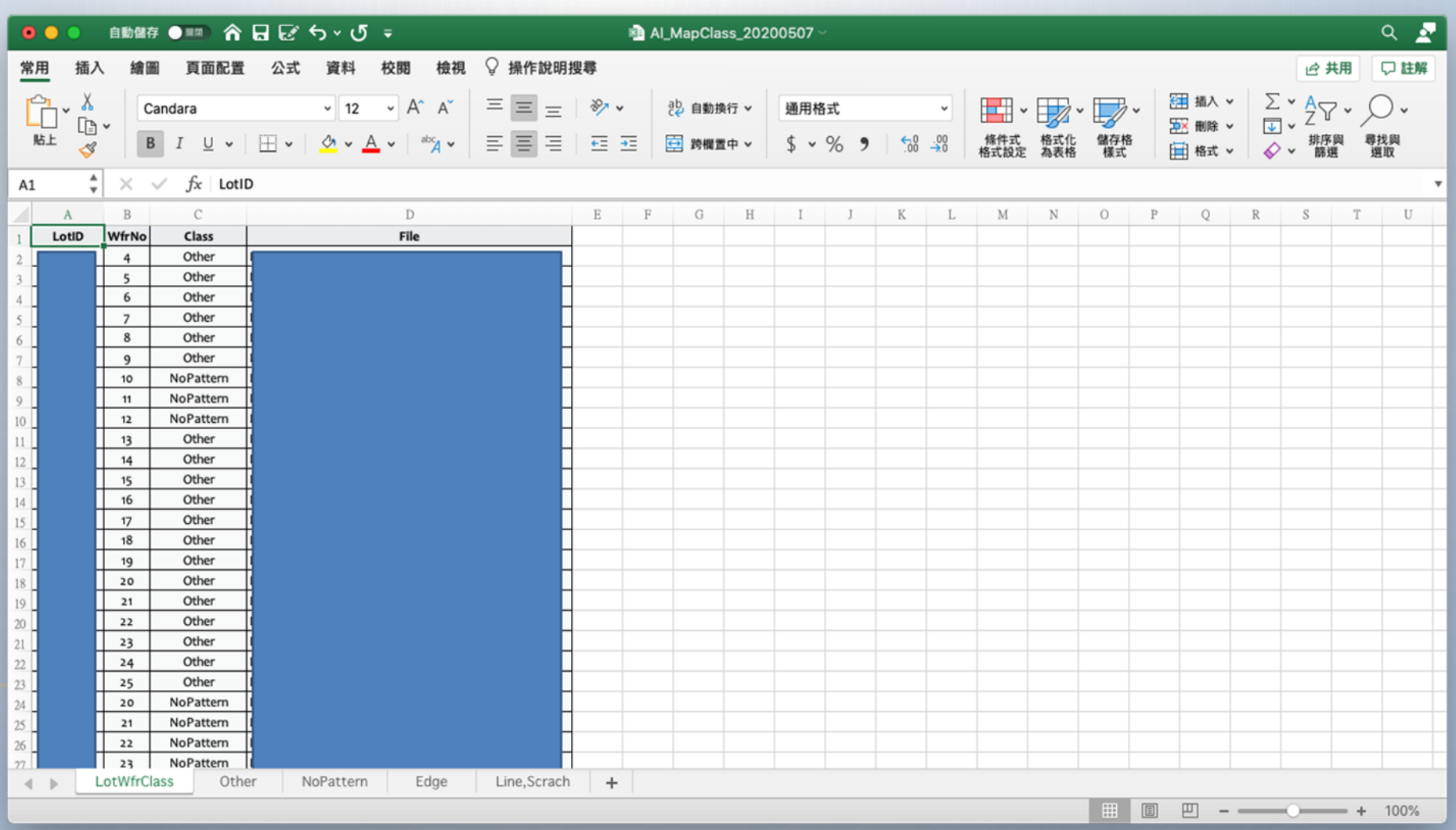
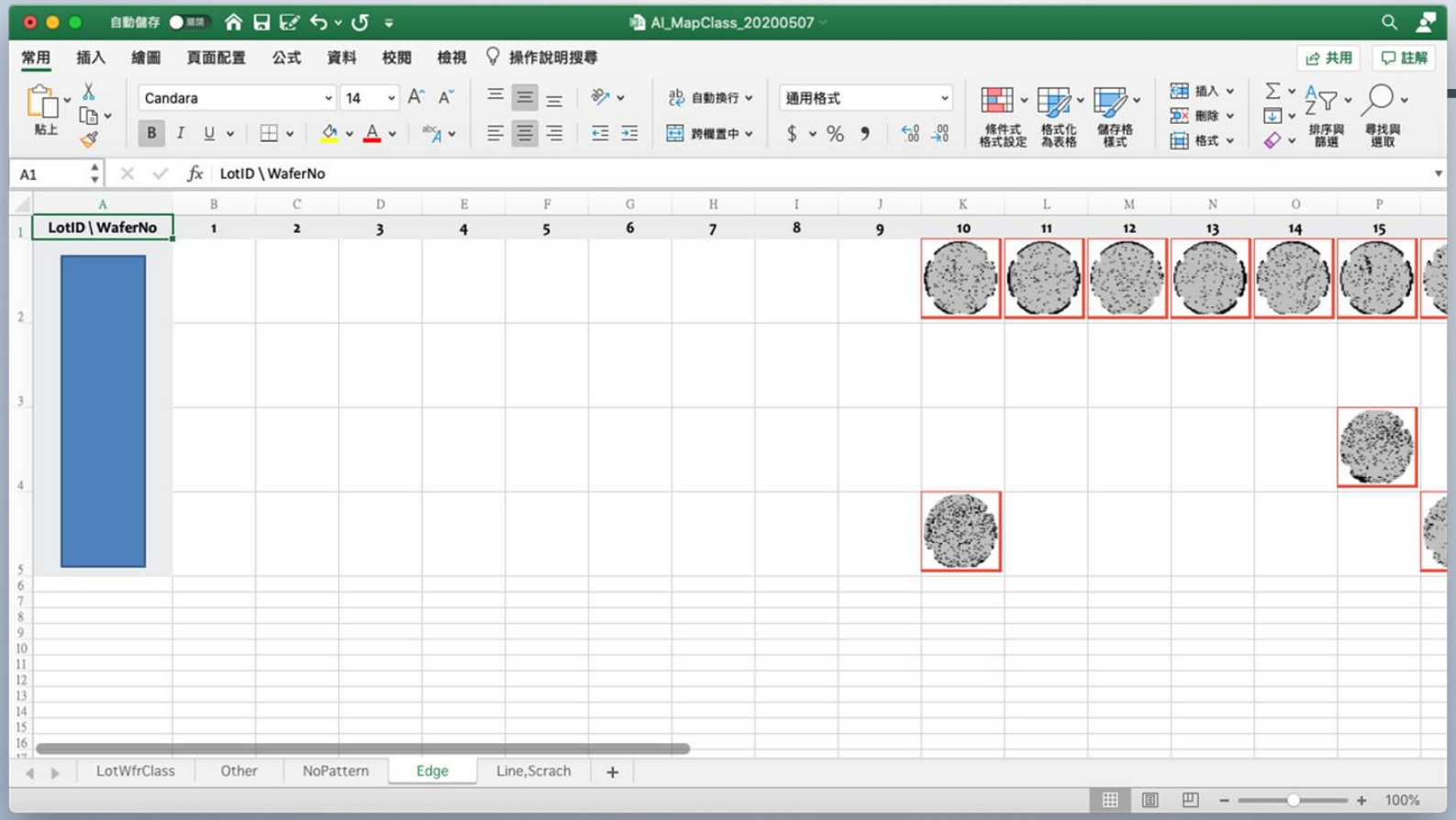


Algorithm Output (as xlsx File)

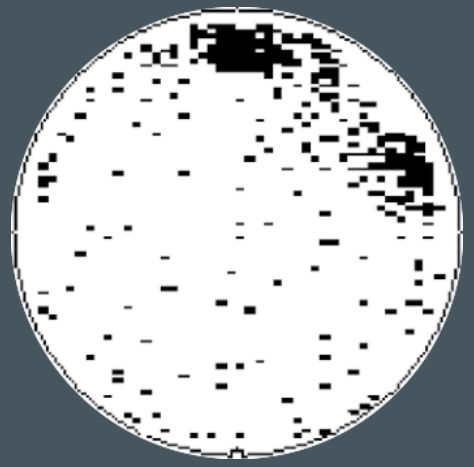


Page 2.

Patterned Map Detection Method: DBSCAN

- **D**ensity-**B**ased **S**patial **C**lustering of Applications with **N**oise
- 針對 map 上的 fail die 先濾除雜點，再進行分群，
  若偵測到群聚 (at least 1 cluster) 則認為此 map 有pattern

Original Map

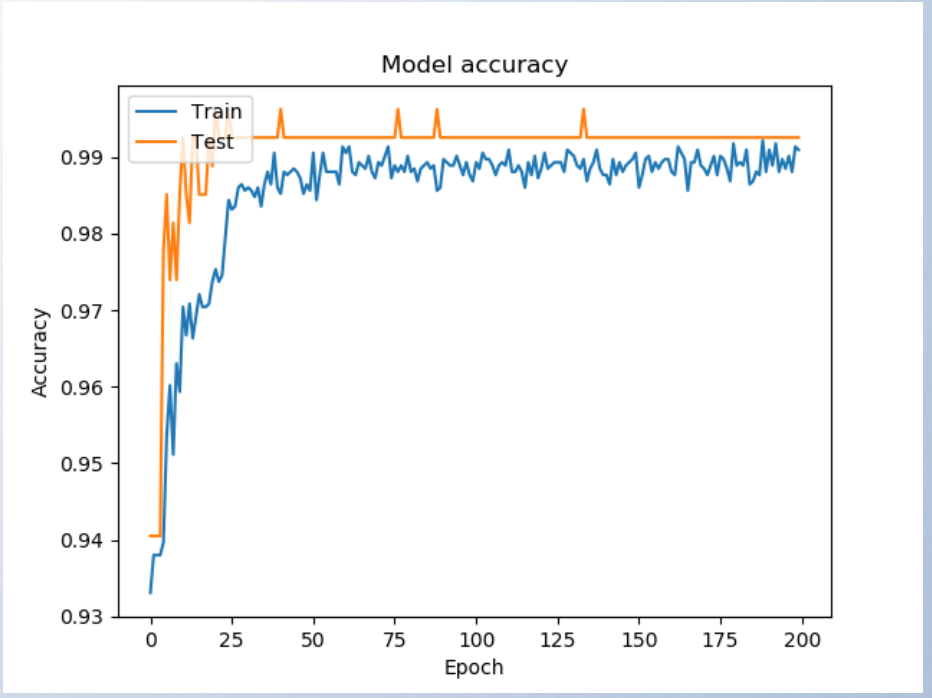


Denoised by Median Filter

DBSCAN Clustering

Edge/Non-Edge Classifier: CNN Model

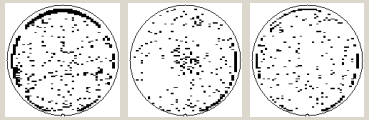
- Training & Testing Data
  - Criteria
    - Vendor: Customer A
    - Time: 2020/03/01 – 2020/03/31
    - Image Size: 60*60 (pixel)
  - Label
    - Edge: 167 maps (不區分整圈/非整圈)
    - Non-Edge: 2538 maps
  - Testing data 由 training 中隨機抽出 10%

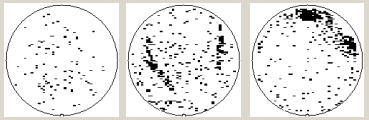


Page 1.

Edge/Non-Edge Classifier: CNN Model

Page 2.

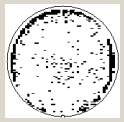
Edge  ...

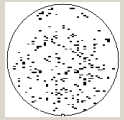
Non-Edge  ...

Manually Labeling Data
(2 sec per images)

Model Training-Let machine learn by examples
(2hs for 2700 images)

Automatically Classifying Data
(25sec for 2700 images)

Edge  ...

Non-Edge  ...

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CNN Model Setting

Use 12 hidden layers to extract features from wafer maps, with zero ‘padding’ to maintain the boundary feature.

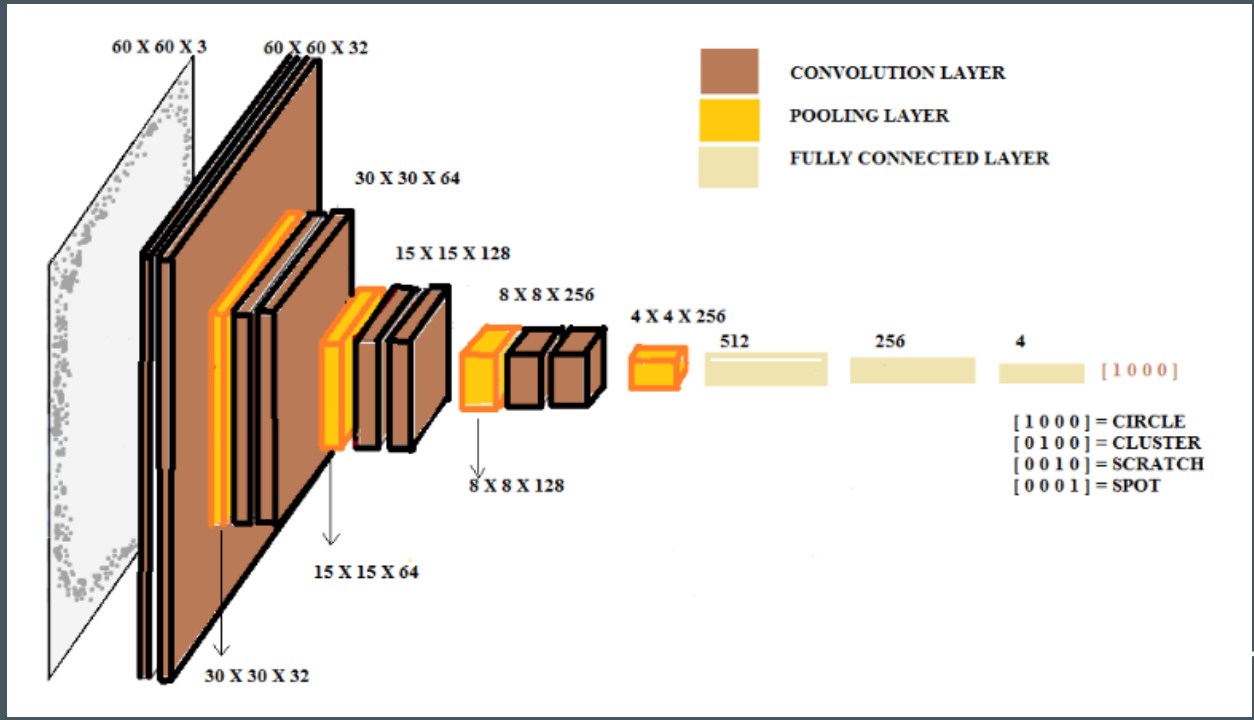

TABLE I
SPECIFICATIONS OF CLASSIFIER

Layer	Dimensions
input	(60× 60)
convolution layer 1	32 (2× 2)
convolution layer 2	32 (2× 2)
max pooling	(2 × 2)
convolution layer 3	64(2 × 2)
convolution layer 4	64(2× 2)
max pooling	(2 ×2)
convolution layer 5	128 (2 × 2)
convolution layer 6	128 (2 × 2)
max pooling	(2 × 2)
convolution layer 7	256 (2×2)
convolution layer 8	256 (2× 2)
max pooling	(2 × 2)

CNN Model Training & Tuning Steps

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Training Stage

Export Images Data from DB
(by cp.exp_png)

↓

Manually Label
Data

↓

Modeling

↓

.h5 File
(Model info.)

- **Supervised learning 需事先給答案**
- Unsupervised learning 不需事先給答案

Inference Stage

New Image

.h5 File
(Model info.)

Inference

File	Label
20200326003524.png	Edge
20200315201525.png	Edge
20200301002816.png	Non-Edge
...	

Tuning Stage

.h5 File
(Model info.)

↑

Modeling

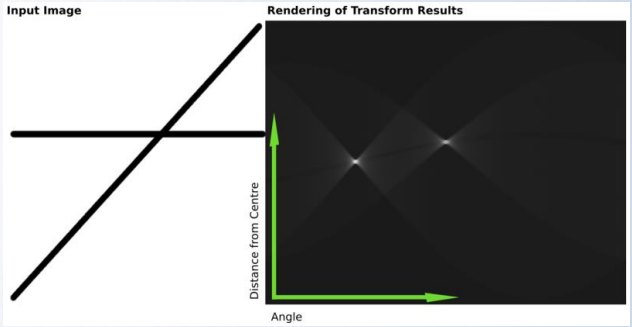
↑

File	Label
20200326003524.png	Edge
20200315201525.png	Non-Edge
20200301002816.png	Non-Edge
...	

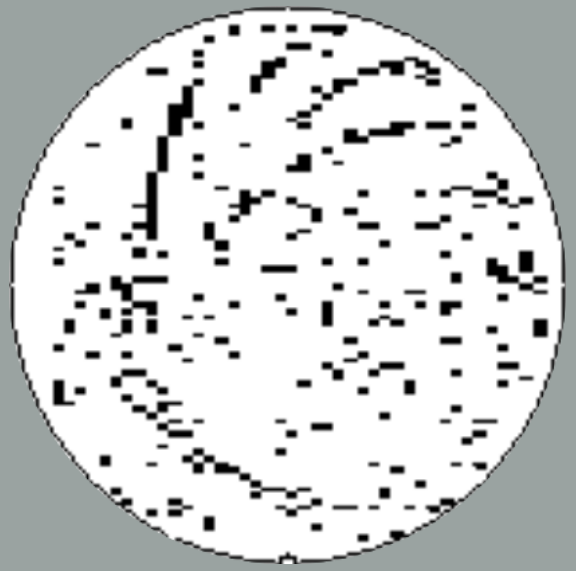
未來經由使用者回饋，可使知識庫得以累積，
並透過模型 tuning 得到越來越高的準確率！

Line/Scratch Detection Method: Hough Transform

- Idea：不同的r, θ 可代表平面上每一條線
- 作法：針對MAP上的Fail Die先濾除雜點,
  在偵測圖形上是否有明顯的直線

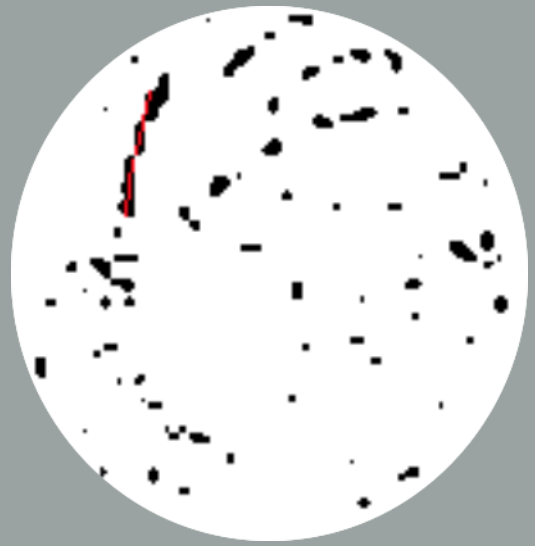


Original Map



Denoised by Median Filter

Line Detection



Summary

- 目前可偵測出哪些 map 有 pattern (不需 user 事先定義)
- 再將偵測到的 pattern 細分為 Edge/Line/Other 三種
- 以 2705 片 try run overall 流程約花3 分鐘分類完成
- 未來再強化分類方法、增加其他 pattern、建立 user feedback 機制

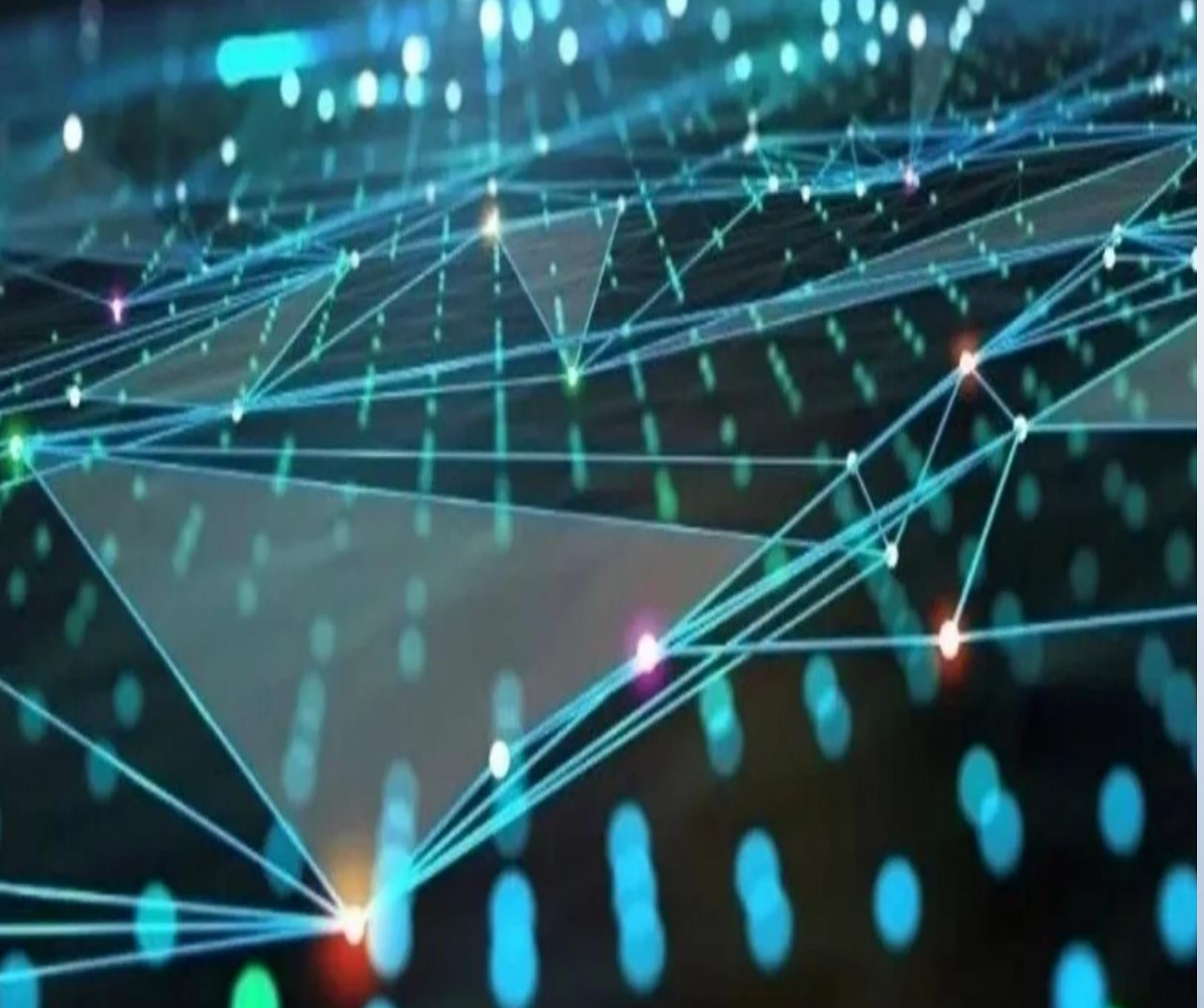
Questions

CONTACT TANGO-AI

https://itanggo.com

+86-18516070025

enquiry@itanggo.com



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Thank You