基礎生醫影像處理技術

Term Project Proposal

Unsupervised Segmentation of Pathology Images based on Haralick Textures

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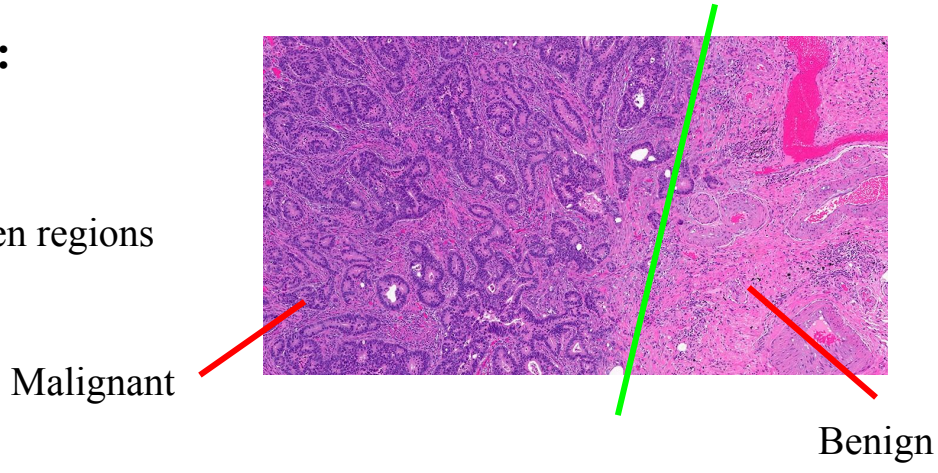
計畫目標 Project Goals

❖ **病理切片 Biopsy Images 之特性：**

- ➢ ill defined margins
- ➢ Image changes dramatically between regions and intra-regional areas.



→ 利用影像處理進行 Biopsy Image Segmentation → ***減少耗費時間，提升 Accuracy***

→ 進行影像分析，提取更多影像資料提供給醫師或是其他診斷用AI模型 → ***提升決策能力***

傳統方法 Traditional Methods

- **Thresholding** (Local, Adaptive)
- **Edge Detection** (Sobel Operator)
- **Region-Based Methods** (Region Growing, Watershed Algorithm)
- **Morphological Operations** (Erosion, Dilation …etc.)

➔ Mostly are ***First Order Statistics*** image analysis

傳統方法 Traditional Methods

Pros

- Simple and Straight Foward
- Low Computational Cost
- Effective for Controlled Scenarios
- Less Data-Dependent
- Faster Development

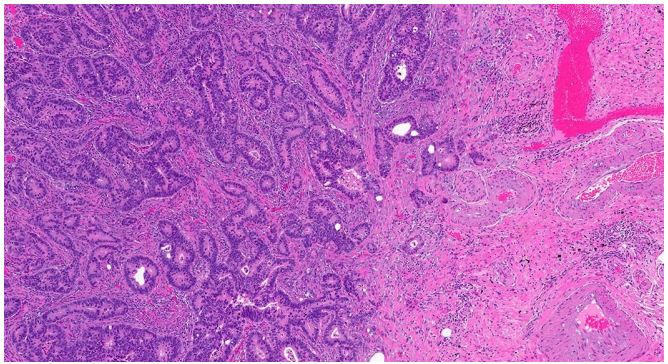
Cons

- Lack of Generalizability
- Manual Feature Engineering
- Lower Accuracy
- Sensitive to Noise
- Limited Adaptability
- Scalability Issues

傳統方法 Traditional Methods

"Such features involve the values of individual pixels, but ignore the spatial interaction between pixels.

Histogram features ***do not reflect objects or patterns in the image, only the distribution of gray-levels****. "* [1]



Original Image

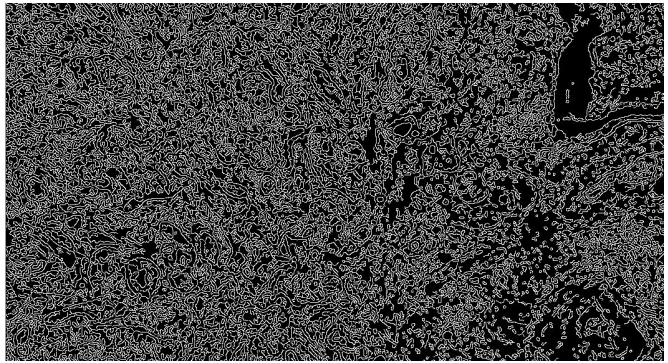


Image after applying Sobel Operator

➔ This inability makes first order statistics a blunt tool for quantifying changes in images, or any change in the spatial distribution of gray values.

[1] Löfstedt, T., Brynolfsson, P., Asklund, T., Nyholm, T., & Garpebring, A. (2019). Gray-level invariant Haralick texture features. PLOS ONE, 14(2), e0212110. https://doi.org/10.1371/journal.pone.0212110

計畫切入點 Project Approach

- Utilize a Normalized GLCM matrix to construct a modified set of Haralick texture features that are asymptotically invariant to the image quantization.
- The computed Haralick features can be further used in image segmentation, an image pattern will give the same texture feature values independent of image quantization.
- Therefore, image segmentation will be performed via pattern, instead of local gray values surrounding a particular pixel.

➔ By leveraging texture analysis, the approach offers *more accurate and reliable image segmentation*, compared with the traditional methods which uses first order statistic analysis, supporting improved diagnostic capabilities

計畫切入點 Project Approach

- **Model Training**

  → Use the computed Haralick Features to train a model that can perform auto-segmentation

- **Advantages:**

  → Adaptability to Complex Patterns

  → Data Efficiency

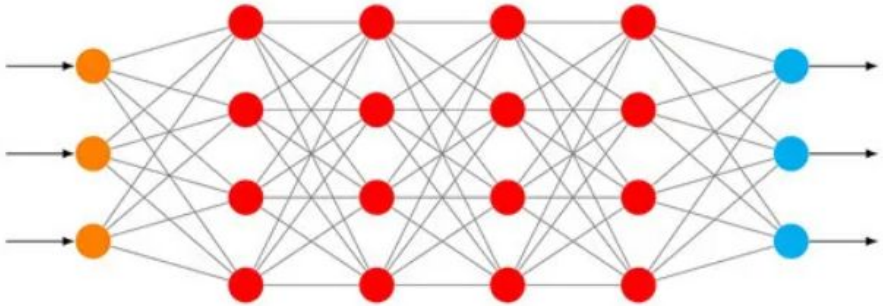
  → Enhanced Segmentation Accuracy

  → Generalization

計畫切入點 Project Approach

- **Input** (Haralick feature vectors.)
- **Hidden Layers**
- **Optimization**

Haralick Feature Vectors



Output

研究方法 Methods

Calculate Haralick features for each pixel region

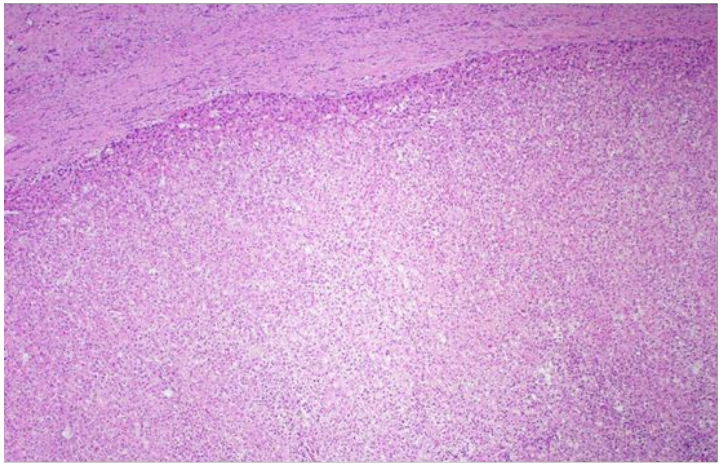
- Convert the image to grayscale or keep it in RGB format
- Use sliding windows with varying sizes (e.g., 3x3, 5x5, 7x7, etc.) to extract surrounding regions
- Compute the Gray-Level Co-Occurrence Matrix (GLCM) and derive 13 Haralick textures features
- Store Haralick textures derived from different window sizes as a detailed feature map for each pixels

研究方法 Methods

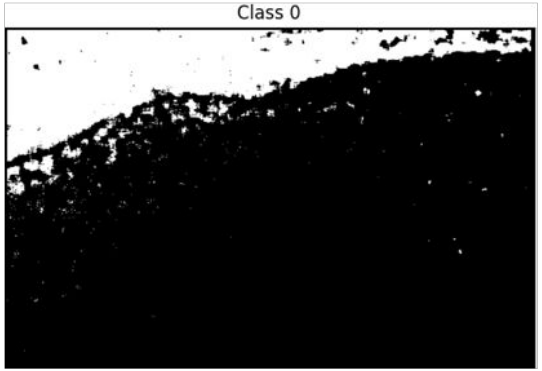
Unsupervised segmentation based on extracted features

- Incorporate Spatial and Pixel Features into the Feature Map
- Dimensionality reduction of the feature map using PCA, t-SNE or other methods
- Using different clustering strategy to perform segmentation
  - K–means
  - Spectral clustering
  - Deep learning-based methods

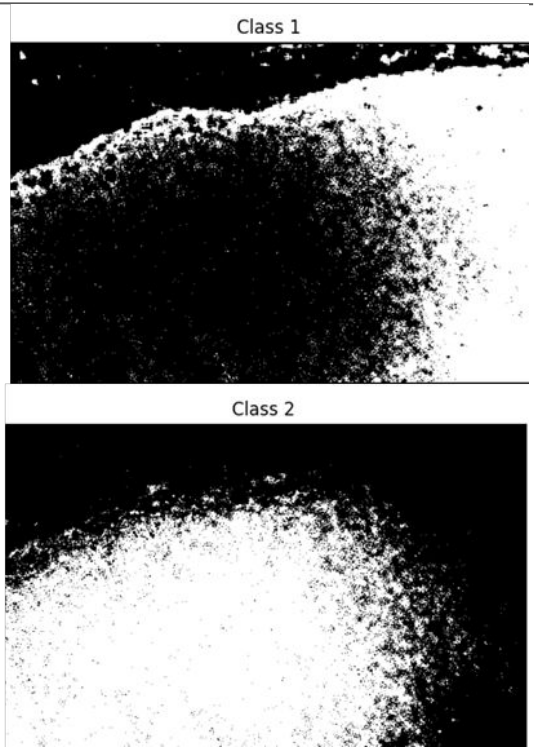
預期分析結果 Expected Outcome



Original Image



Segmentation results



- ➔ Refine segmentation results with opening, closing strategies
- ➔ Derive Quantifiable Segmentation Evaluation Metrics

參考資料 References

[1] Löfstedt, T., Brynolfsson, P., Asklund, T., Nyholm, T., & Garpebring, A. (2019). Gray-level invariant Haralick texture features. PLOS ONE, 14(2), e0212110. https://doi.org/10.1371/journal.pone.0212110

[2] Naira Elazab, Wael Gab Allah, & Elmogy, M. (2024). Computer-aided diagnosis system for grading brain tumor using histopathology images based on color and texture features. BMC Medical Imaging, 24(1). https://doi.org/10.1186/s12880-024-01355-9

[3] Öztürk, Ş., & Akdemir, B. (2018). Application of Feature Extraction and Classification Methods for Histopathological Image using GLCM, LBP, LBGLCM, GLRLM and SFTA. Procedia Computer Science, 132, 40–46. https://doi.org/10.1016/j.procs.2018.05.057

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[5] Eizan Miyamoto1 and Thomas Merryman Jr.2, Fast calculation of haralick texture features