A Content-Based Medical Image Retrieval for Pap Smear Images with Generative Adversarial Networks and Nearest Neighbor

Camilo Núñez Fernández

Departamento de Informática

16 de Enero del 2023

Problem - Background

Objective disease: Cervical Cancer

Objective method: Cervical smear images $\longrightarrow$ Papanicolaou Smear

Some problems in Papanicolaou Smear Analysis

- The screening process is expensive and time-consuming: this process take around 5 to 10 minutes based on the difficulty of cell. A cytothecnologist cannot analyse more than 70 samples on a day [1].
- The process also generate a large scale images that could affect the process with more delays in the workflow [2].

Basic Solution: A Content-Based Medical Image Retrieval (CBMIR) service for Pap smear images, aimed to computer-aided diagnosis (CAD).

Problem - Definition

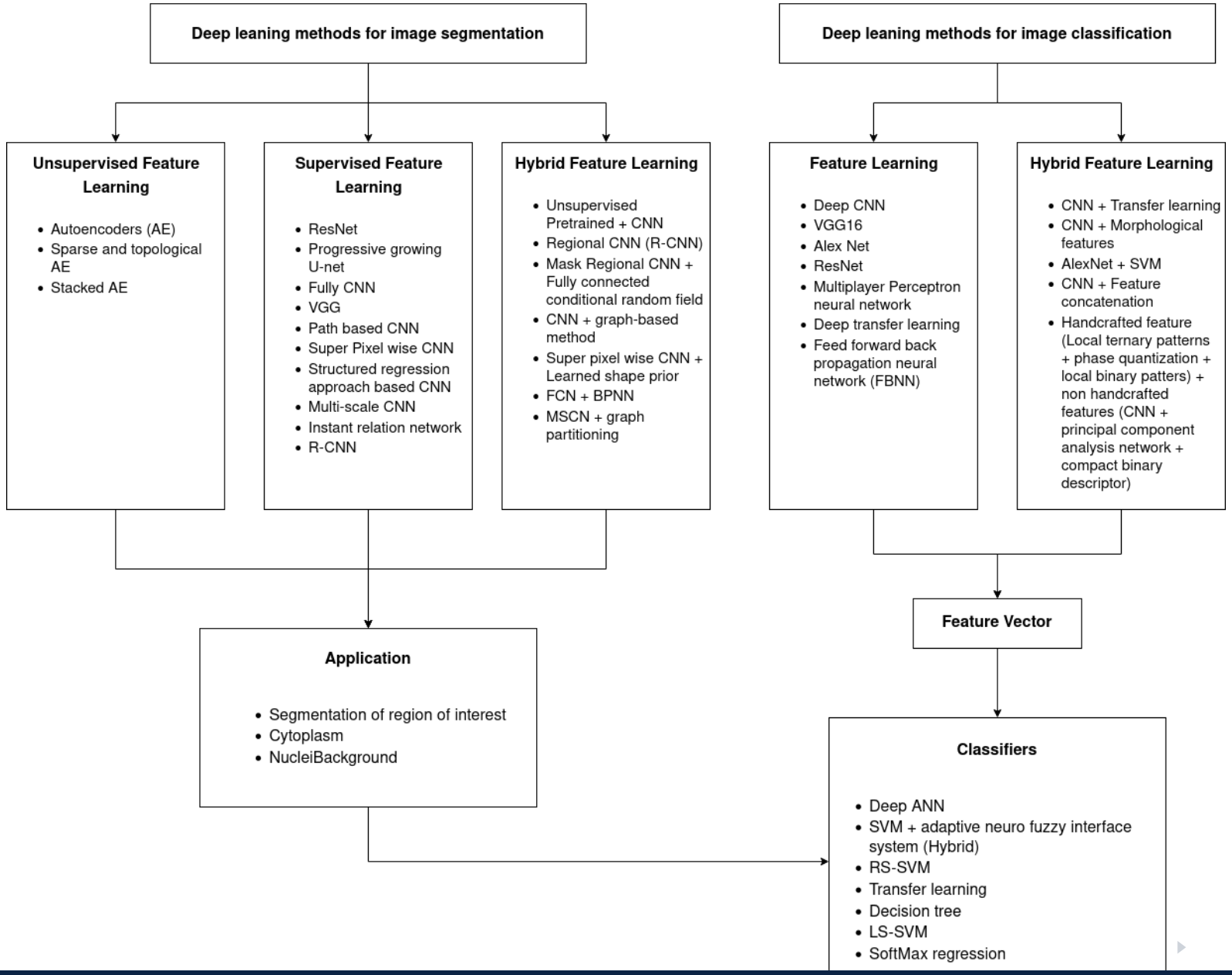
Basic Solution: A Content-Based Medical Image Retrieval (CBMIR) service for Pap smear images, aimed to computer-aided diagnosis (CAD).

Involvements Basic Solution:

- Inefficient retrieves (i e. bad solution for overlapping cells [3], absence of feedback-based options [4])
- Hard dependencies over the handcraft-annotations [5].
- Losses in the semantic of the images [2].

Complex Solution: An **efficient** Content-Based Medical Image Retrieval (CBMIR) with **robust and richness features vectors** for pap smear images.

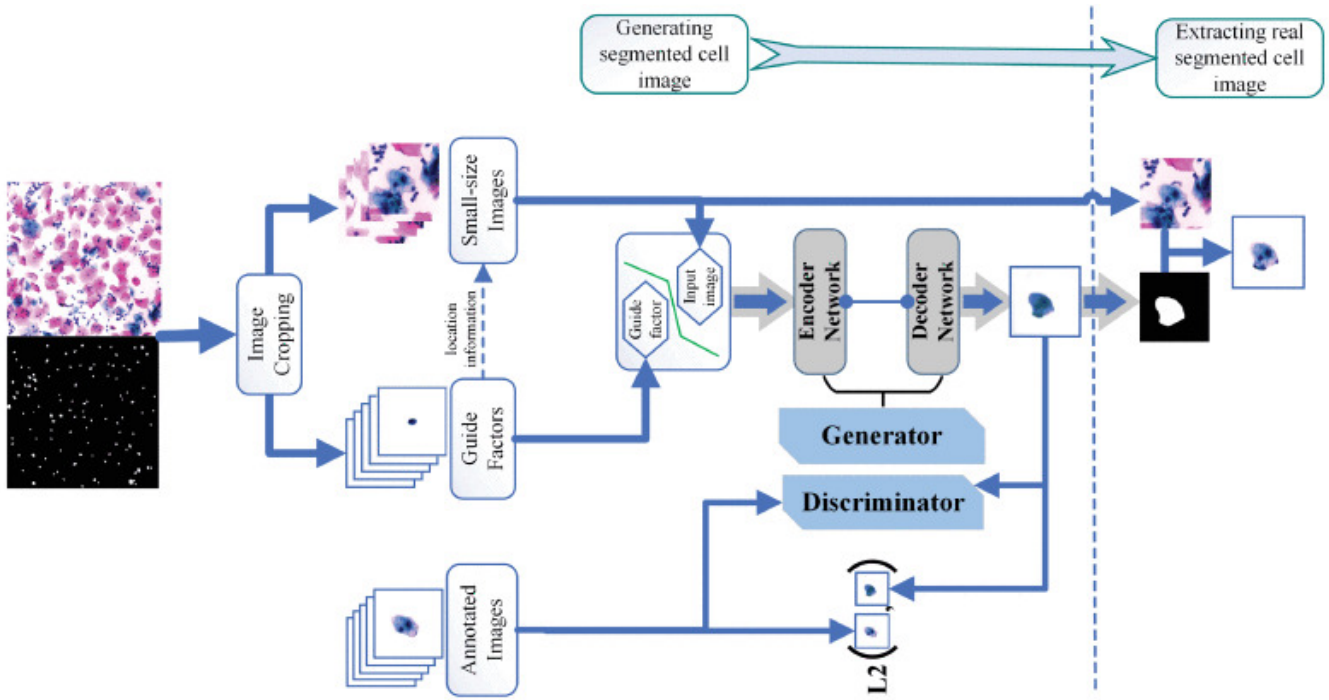
Related Work - Deep Learning - Classic Arqs



Related Work - Deep Learning - SOTA

Generative Adversarial Networks - Cell-GAN [6]

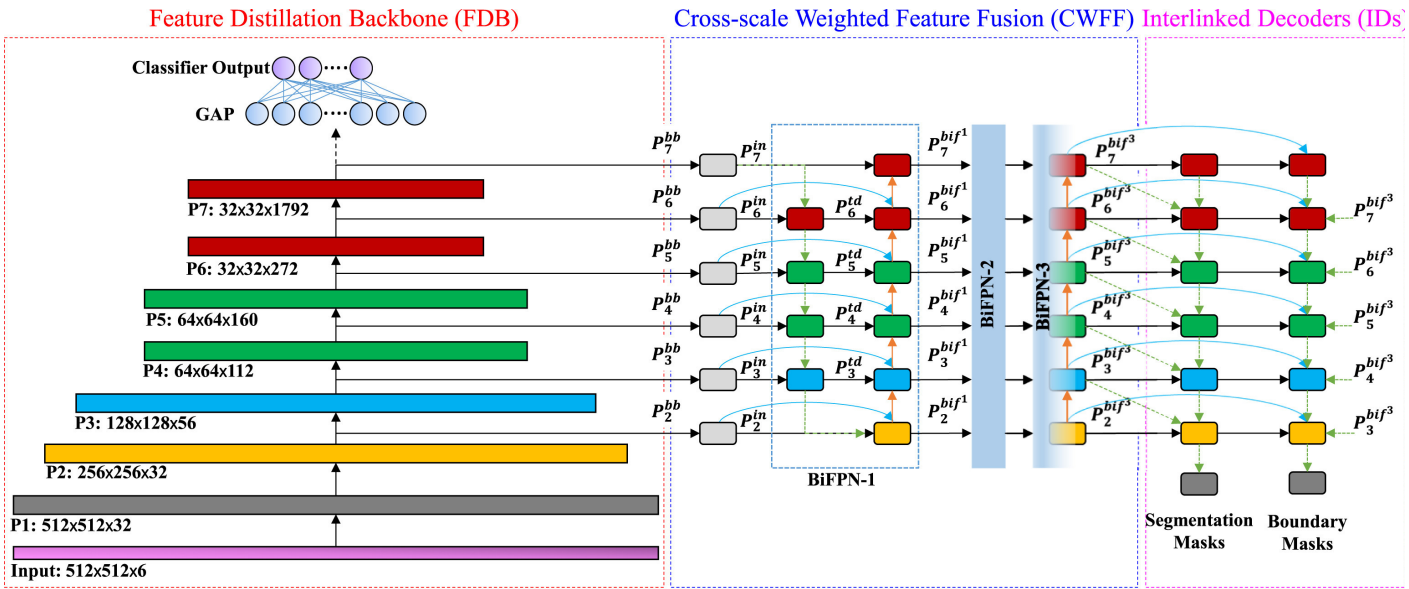
- Segmentation of cervical cell images
- Encoder-Decorder with double input generator
- Guide factor as prior
- Inception architecture discriminator



Related Work - Deep Learning - SOTA

Tissue specific feature distillation network (TSFD-Net) [7]

- Multi-task network: classification and segmentation (semantic and boundary)
- Three stages:
  1. Feature distillation backbone with Mobile-Net-v2 and squeeze-excitation sub-network
  2. **Feature combinations** with cross-scale weighted feature fusion (CWFF) paths
  3. Interlinked decoders for semantic mask and boundary mask



Proposal (I)

Design and development of an efficient framework for CBMIR with:

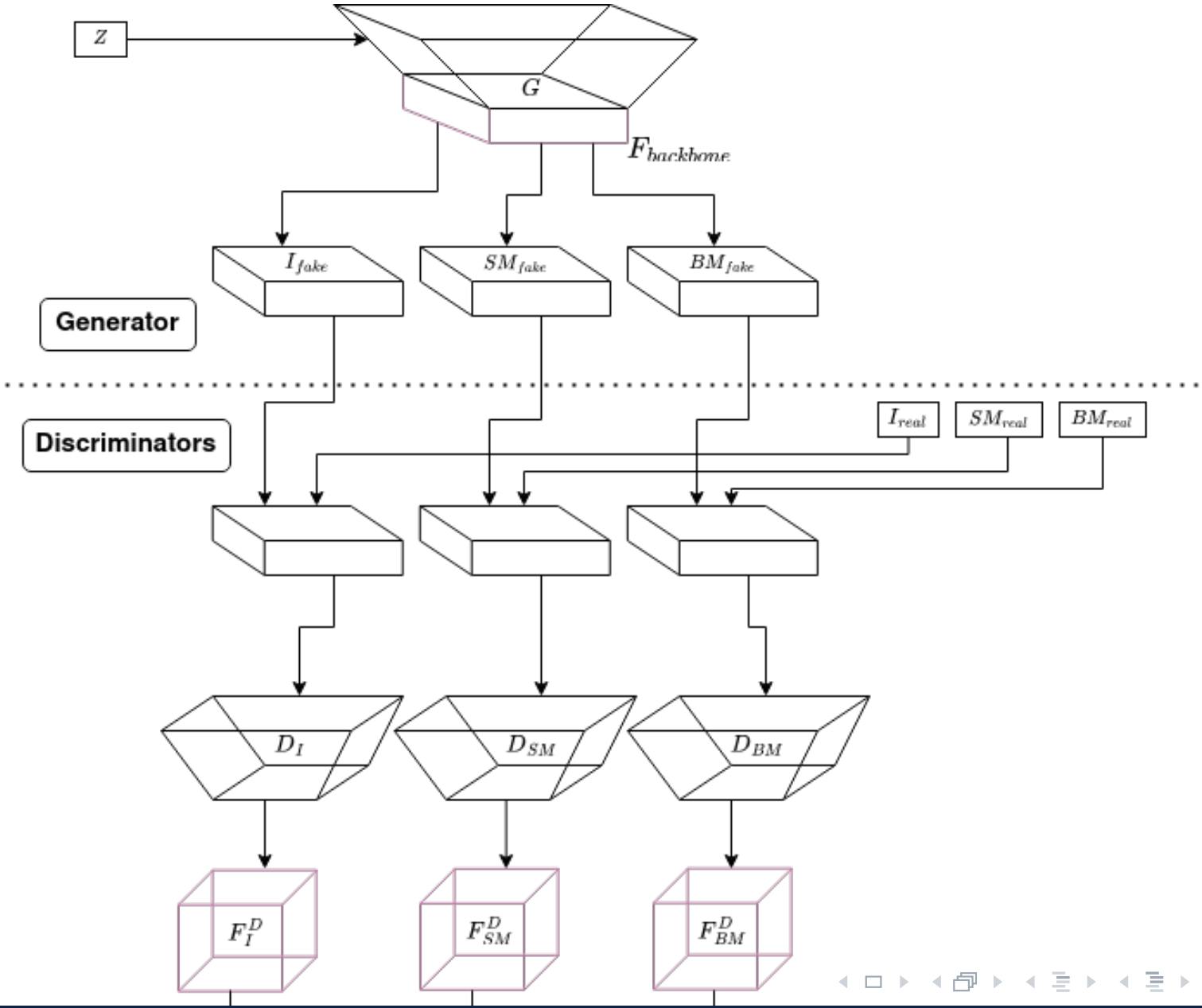
- Novel generative neural network for the feature extraction of pap smear images
- Optimal retrieval with graph-based nearest neighbour algorithm

Novel generative neural network

- One big generator: multi-task network for classification and segmentation (semantic and boundary)
- Three discriminators
- Investigate and analyse the combination of features vectors aimed for a robust and richness embeddings (i e. combs for $F_I^D, F_{SM}^D, F_{BM}^D, F_{backbone}$)

Optimal retrieval: *HNSW* [8, 9] according to the benchmark of *Aumüller M. et al.* [10]

Proposal (II)


Z
G
$F_{backbone}$
I_{fake}
SM_{fake}
BM_{fake}
Generator
Discriminators
I_{real}
SM_{real}
BM_{real}
D_I
D_{SM}
D_{BM}
F_I^D
F_{SM}^D
F_{BM}^D

Hypothesis

Hypothesis

- It's possible generate multiples *features vectors* that could be more robust and efficient to be used by a *CMBIR* for pap smear images, using a generative neural network to classification and segmentation.
- The proposed *CMBIR* is capable of maintain or exceed the time and efficiency in the retrieval of pap smear images with respect to others *CMBIR* of the state of the art.

Resources

Data sets pap smear imgs

- ISBI Challenges: ISBI 2014 and 2015 challenges dataset with 945 images and 17 images respectively. Included overlapping cells. [11][12].
- Herlev dataset: 917 isolated sigle-cell images [13][14][15][16].
- SIPaKMeD: 4049 isolated sigle-cell images [17].
- liquid-based cytology Pap smear dataset: 963 full images [18].

Metrics

- *CBIR metrics*: precision y recall
- *Generated objects*:
  - Images: inception score (IS) and Frechet inception distance (FID)
  - Mask: dice coefficient

Tools

- *PyTorch*: Network
- *HNSW*: Nearest neighbour search
- *Django*: Back-end - API REST

Extra

Transfer learning with multiple nuclei images

- Train a backbone with multiple datasets of nuclei images
- Use different tissue types
  - PanNuke[1]: 205,343 labeled images (19 types)
  - HoVer-Net[2]: 24,319 images
  - EBHI-Seg[3]: 5,170 images (6 types)

[1] https://jgamper.github.io/PanNukeDataset/
[2] https://warwick.ac.uk/fac/cross_fac/tia/data/hovernet/
[3] https://figshare.com/articles/dataset/EBHI-SEG/21540159/1

Thanks !

References I

Elsheikh, T. M., Austin, R. M., Chhieng, D. F., Miller, F. S., Moriarty, A. T., and Renshaw, A. A., "American society of cytopathology workload recommendations for automated pap test screening: Developed by the productivity and quality assurance in the era of automated screening task force," *Diagnostic Cytopathology* **41**, 174–178 (Feb. 2012).

Rahaman, M. M., Li, C., Wu, X., Yao, Y., Hu, Z., Jiang, T., Li, X., and Qi, S., "A survey for cervical cytopathology image analysis using deep learning," *IEEE Access* **8**, 61687–61710 (2020).

Zhao, C., Shuai, R., Ma, L., Liu, W., and Wu, M., "Improving cervical cancer classification with imbalanced datasets combining taming transformers with t2t-ViT," *Multimedia Tools and Applications* **81**, 24265–24300 (Mar. 2022).

Sampaio, A. F., Rosado, L., and Vasconcelos, M. J. M., "Towards the mobile detection of cervical lesions: A region-based approach for the analysis of microscopic images," *IEEE Access* **9**, 152188–152205 (2021).

Müller, H., Michoux, N., Bandon, D., and Geissbuhler, A., "A review of content-based image retrieval systems in medical applications—clinical benefits and future directions," *International Journal of Medical Informatics* **73**, 1–23 (Feb. 2004).

Huang, J., Yang, G., Li, B., He, Y., and Liang, Y., "Segmentation of cervical cell images based on generative adversarial networks," *IEEE Access* **9**, 115415–115428 (2021).

References II

- Ilyas, T., Mannan, Z. I., Khan, A., Azam, S., Kim, H., and Boer, F. D., "TSFD-net: Tissue specific feature distillation network for nuclei segmentation and classification," *Neural Networks* **151**, 1–15 (July 2022).
- Malkov, Y. A. and Yashunin, D. A., "Efficient and robust approximate nearest neighbor search using hierarchical navigable small world graphs," *IEEE Transactions on Pattern Analysis and Machine Intelligence* **42**, 824–836 (2016).
- Boytsov, L. and Naidan, B., "Engineering efficient and effective non-metric space library," in [*Similarity Search and Applications*], (2013).
- Aumüller, M., Bernhardsson, E., and Faithfull, A., "Ann-benchmarks: A benchmarking tool for approximate nearest neighbor algorithms," (2018).
- Lu, Z., Carneiro, G., and Bradley, A. P., "An improved joint optimization of multiple level set functions for the segmentation of overlapping cervical cells," *IEEE Transactions on Image Processing* **24**(4), 1261–1272 (2015).
- Lu, Z., Carneiro, G., Bradley, A. P., Ushizima, D., Nosrati, M. S., Bianchi, A. G. C., Carneiro, C. M., and Hamarneh, G., "Evaluation of three algorithms for the segmentation of overlapping cervical cells," *IEEE Journal of Biomedical and Health Informatics* **21**, 441–450 (Mar. 2017).

References III

Marinakis, Y., Dounias, G., and Jantzen, J., "Pap smear diagnosis using a hybrid intelligent scheme focusing on genetic algorithm based feature selection and nearest neighbor classification," *Computers in Biology and Medicine* **39**, 69–78 (Jan. 2009).

Dounias, G. D., Bjerregaard, B., Jantzen, J., Tsakonas, A., Ampazis, N., Panagi, G., and Panourgias, E., "Automated identification of cancerous smears using various competitive intelligent techniques.," *Oncology reports* **15 Spec no.**, 1001–6 (2006).

Ampazis, N., Dounias, G., and Jantzen, J., "Efficient second order neural network training algorithms for the construction of a pap-smear classifier," *Lecture Notes in Artificial Intelligence* **3025** (01 2004).

Jantzen, J. and Dounias, G., "Analysis of pap-smear image data," in [*Proceedings of the Nature-Inspired Smart Information Systems 2nd Annual Symposium*], NiSIS (2006). Nature-Inspired Smart Information Systems 2nd Annual Symposium ; Conference date: 01-01-2006.

Plissiti, M. E., Dimitrakopoulos, P., Sfikas, G., Nikou, C., Krikoni, O., and Charchanti, A., "Sipakmed: A new dataset for feature and image based classification of normal and pathological cervical cells in pap smear images," in [*2018 25th IEEE International Conference on Image Processing (ICIP)*], 3144–3148 (2018).

References IV

Hussain, E., Mahanta, L. B., Borah, H., and Das, C. R., "Liquid based-cytology pap smear dataset for automated multi-class diagnosis of pre-cancerous and cervical cancer lesions," *Data in Brief* **30**, 105589 (June 2020).