PhD Student Challenge

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For St. Anna Kinderkrebsforschung

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Summary

The PhD Student Challenge

Approach:

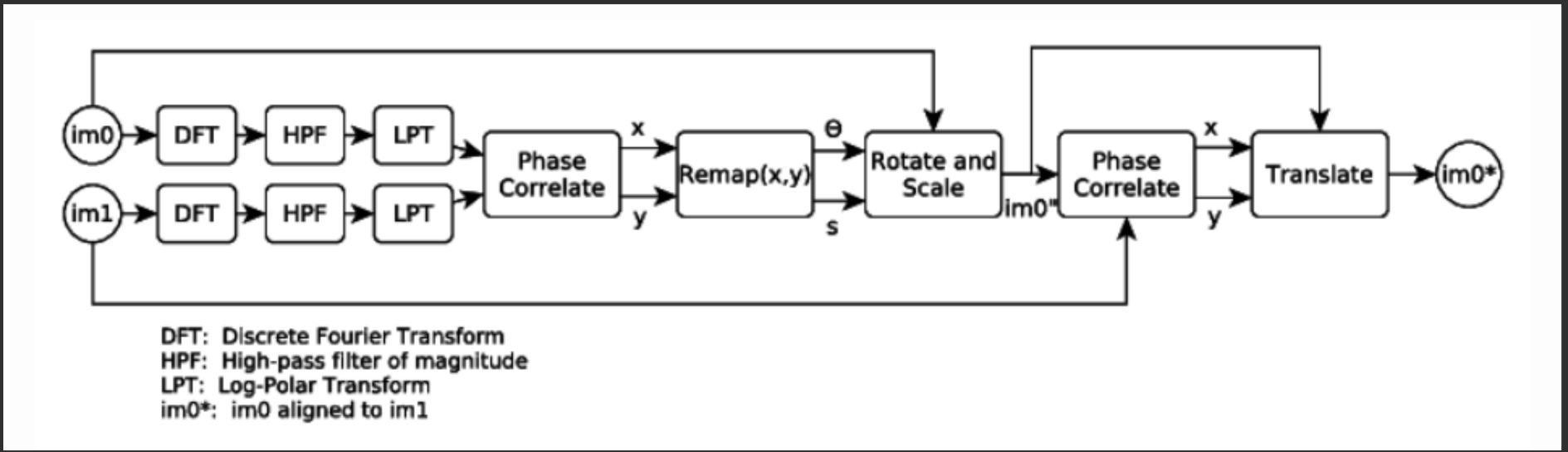
- Interpretability is underrated and most Deep Learning (DL) methods are yet to supersede traditional Image Signal Processing (ISP) solutions in this regard.
- Analyze the data and explore and intricate details that might help with the task.
- Reflect on my past experiences with the problem or similar problems/theory and concoct a simplistic solution.
- Try and find ways to purposefully fool my proposed solution by identify edge case scenarios for the problem at hand.
- Refer literature and draw ideas/solutions that handle the shortcomings of my approach.
- Integrate ideas to get the best of both worlds!

Task 1: Image Registration Challenges

- The registration algorithms to be used for this task is expected to be rotation, scale, and translation invariant.
- Computational efficiency is equally essential for this task to save time and resources.
- Intensity based registration methods would be insufficient due to a variety of reasons. Ex. Template Matching (Rotation Variant), Optical Flow & Feature Matching Methods (computationally expensive and high likelihood of mismatch due to repeating patterns/features)
- Another aspect to consider while working with large images (and in our case tiles) would be to evaluate the success in registration for each tile and determine the tile(region) corresponding best to a given template.

Task 1: Theory of Image Registration using Fourier-Mellin Transform by *Reddy et al.* [3]

The FMT Registration Pipeline



- This approach basically estimates the similarity transform (translation, rotation and scale) between the source and target image.

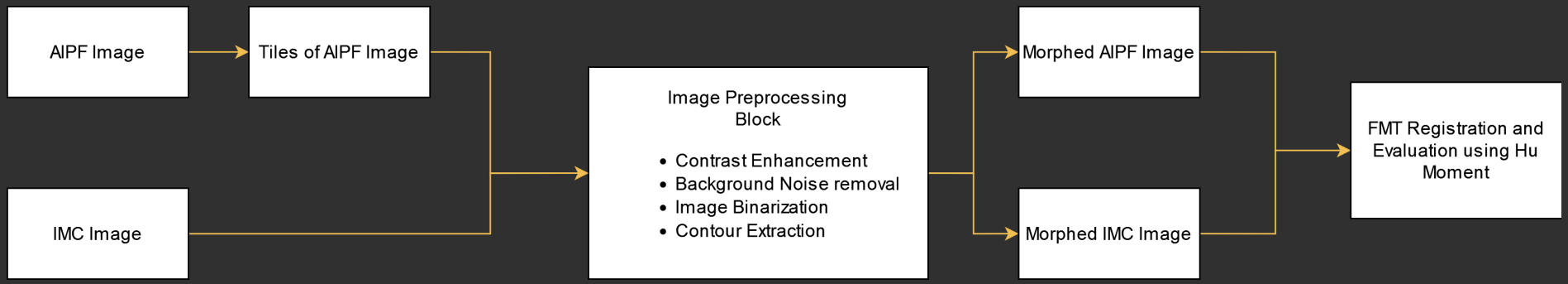
Task 1: Theory of Hu Moments [1]

- Hu Moments is a set of 7 image descriptor that are used to quantify the shape of an object in a given binary image.
- It is invariant to rotation, scale, translation as well as reflection! (Except the 7th moment which is susceptible to reflection.)

Task 1: Theory of Hu Moments

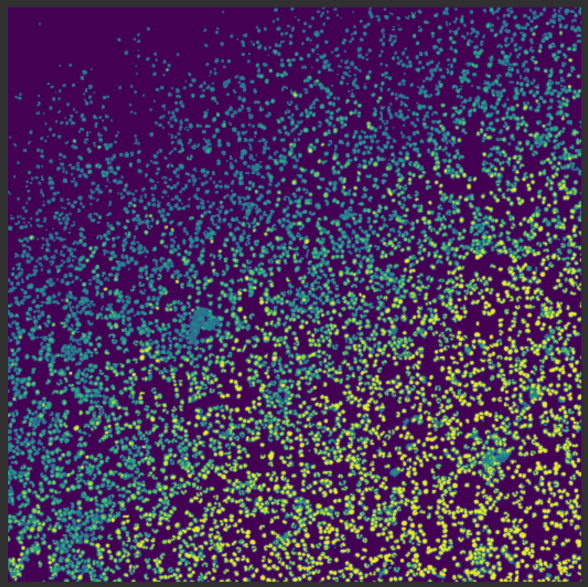
id	Image	H[0]	H[1]	H[2]	H[3]	H[4]	H[5]	H[6]
K0		2.78871	6.50638	9.44249	9.84018	-19.593	-13.1205	19.6797
S0		2.67431	5.77446	9.90311	11.0016	-21.4722	-14.1102	22.0012
S1		2.67431	5.77446	9.90311	11.0016	-21.4722	-14.1102	22.0012
S2		2.65884	5.7358	9.66822	10.7427	-20.9914	-13.8694	21.3202
S3		2.66083	5.745	9.80616	10.8859	-21.2468	-13.9653	21.8214
S4		2.66083	5.745	9.80616	10.8859	-21.2468	-13.9653	-21.8214

Task 1: The Workflow for Image Registration

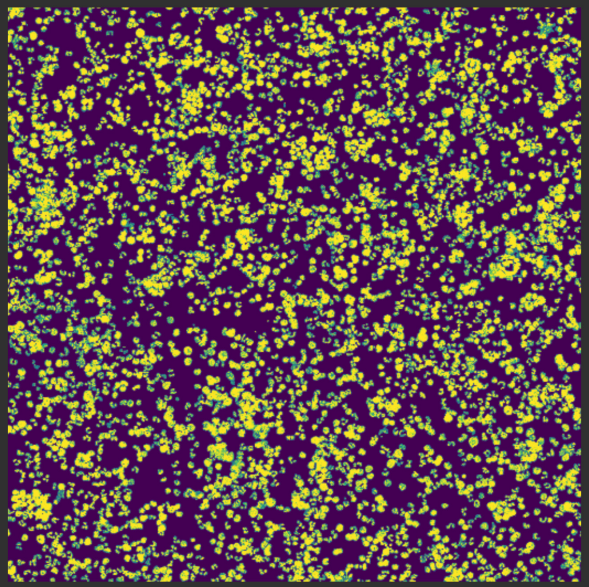


Task 1: Result (Looks fine ?)

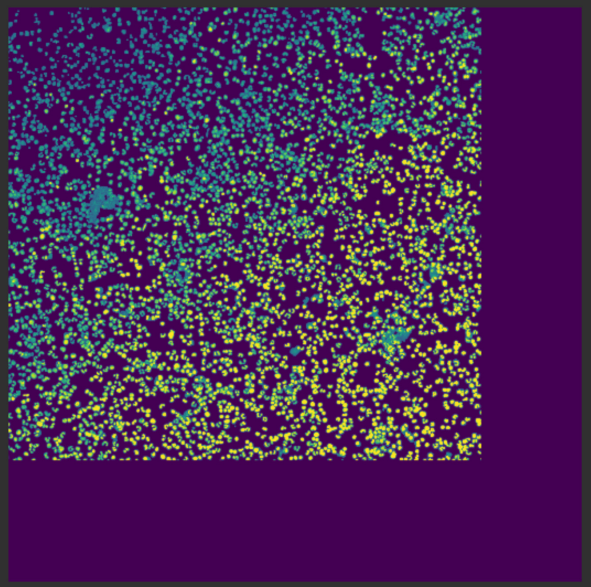
Source Tiled Image



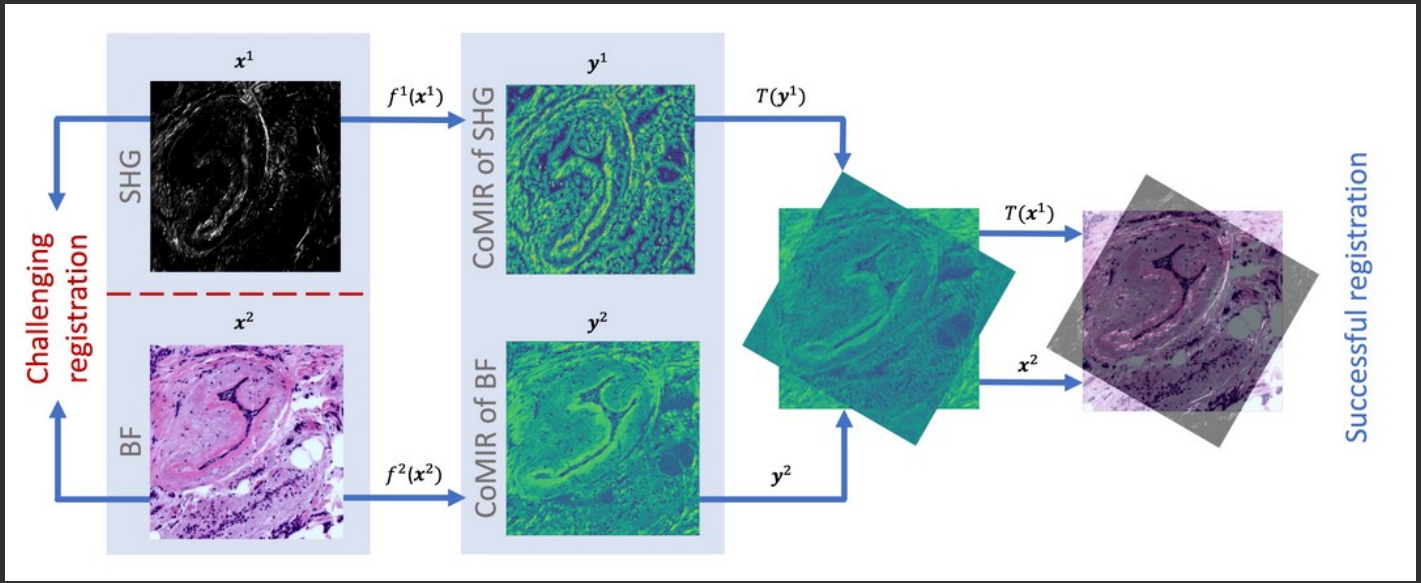
Target Image



Registration Result



Task 1: Future Directions

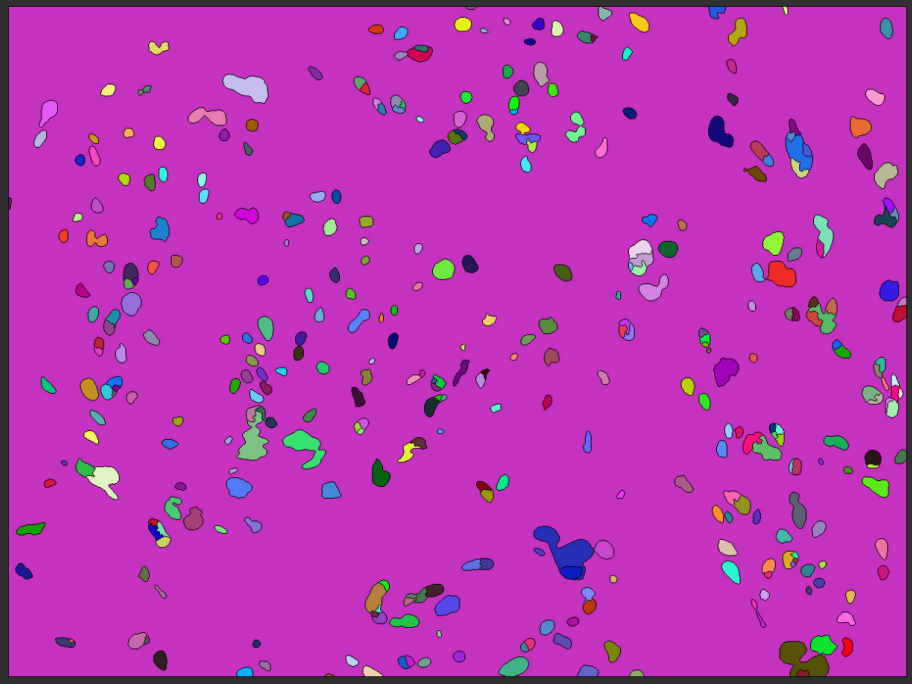


Transforming images into invertible deep latent space (learned space) before aligning them could be an excellent direction to explore. [2].

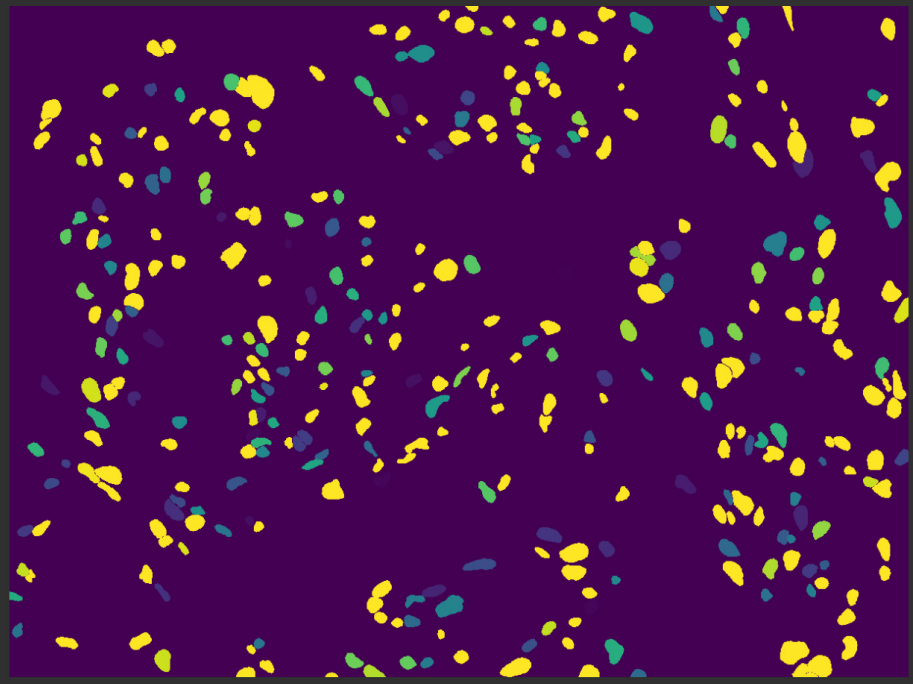
Task 2: Nuclei Segmentation from AIPF using Watershed

- Simple thresholding and morphological processing is inadequate to separate all instances of objects in an image.
- Watershed extremely useful and reliable when extracting touching or overlapping objects (nuclei in our case) in images.
- Grayscale image are viewed as topographic surface where high intensity denotes peaks and hills while low intensity denotes valleys.

Task 2: Result of using watershed



Watershed result

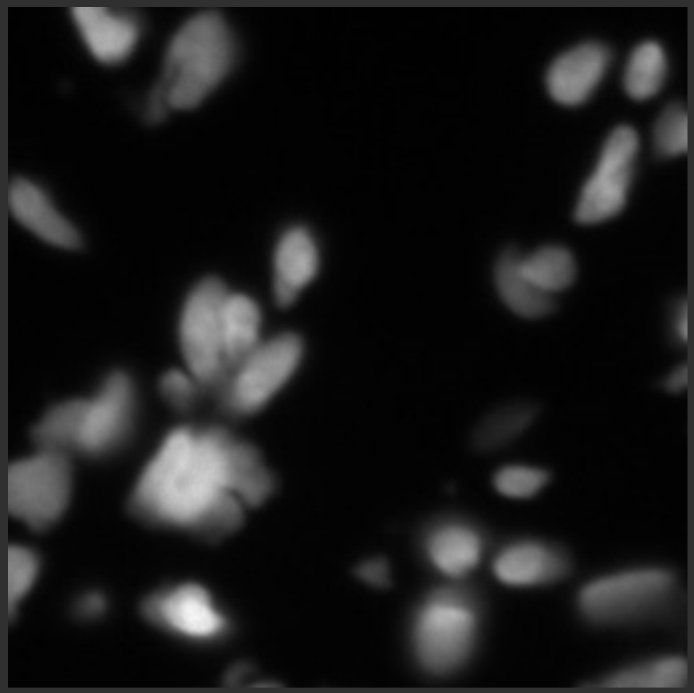


GT mask

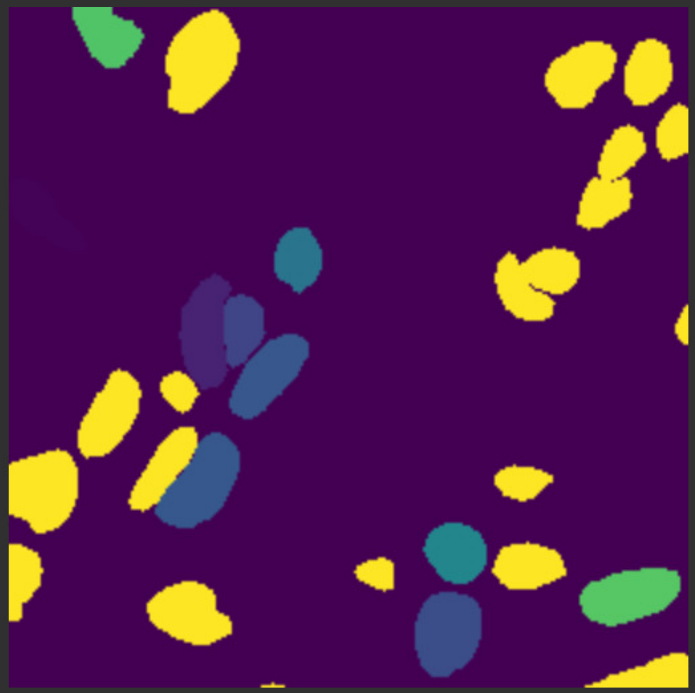
Task 2: Nuclei Segmentation from AIPF by fine-tuning pretrained Mask R-CNN

- Combines Object Detection (classifying target specific objects) and Semantic Segmentation (labelling each pixel)
- Mask R-CNN is built on top of Faster R-CNN
- Pretrained on COCO dataset
- Ground truth segmentation labels seemed noisy and error handling was needed for a variety of scenarios.

Task 2: Result of using Mask R-CNN



Model Prediction



GT Mask

Task 2: Future Directions

- Watershed method could be a good solution for creating a large dataset.
- Noise in the ground truth labels is a cause of concern.
- Self-Supervised DNN networks might be be a good avenue to explore. [4]
- Additionally, watch out for vision transformers!

Task 3 and 4: Feature Extraction and Clustering Ideas

- Features representing aspects of geometry and cell mass intensity have worked well in past studies.
- Hu Moments described earlier could act as another valuable shape descriptor along with "Podczeck shapes vector".
- Similarly pretrained GANs could be leveraged to extract texture information and augment the feature vectors.

Conclusion

Suitability for the current PhD position:

1. My problem solving toolkit includes a good balance of traditional ISP methods as well as Deep Learning methods.
2. Prior experience in integrating individual workflows to achieve a specific goal.
3. Posses a one shot neural network that helps me to translate concepts that I might lack technical expertise in.
4. A good mix of creative and convoluted. (I think!)
5. Could potentially offer a very different perspective.
6. Driven and like to take initiatives.
7. Like to go out of my way to help colleagues/people.

References

- Hu, M.-K. Visual pattern recognition by moment invariants. *IRE transactions on information theory* **8,** 179–187 (1962).
- Pielawski, N. *et al.* Comir: Contrastive multimodal image representation for registration. *arXiv preprint arXiv:2006.06325* (2020).
- Reddy, B. S. & Chatterji, B. N. An FFT-based technique for translation, rotation, and scale-invariant image registration. *IEEE transactions on image processing* **5,** 1266–1271 (1996).
- Sahasrabudhe, M. *et al.* *Self-supervised nuclei segmentation in histopathological images using attention.* in *International Conference on Medical Image Computing and Computer-Assisted Intervention* (2020), 393–402.

The End