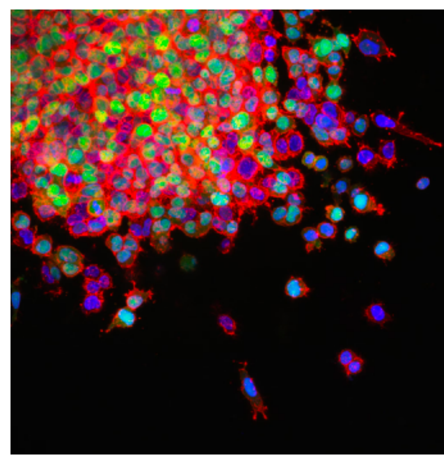
Track 10 – Diagnostic AI

Transforming Healthcare Using Image Processing and Learning from Biomedical Images

Disciplines: *Computer Vision, Biomedical Engineering, Computational Biology, Computer Science, Electrical Engineering*

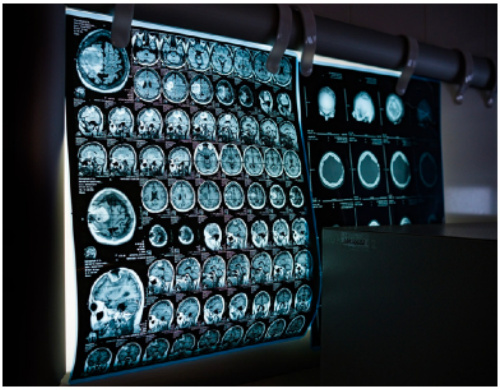
Artificial Intelligence (AI) in medical imaging makes possible diagnostic images that physicians can use, from microscopic images of blood samples to whole brain MRI scans. Without this technology, the intricate details of a cell microscopy image and the ability to see beyond the surface of tissues and organs would be impossible. AI enables researchers to uncover the secrets of cells, identify the warning signs of diseases, and witness the curative powers of surgery or medicine. However, without accurate image analysis, this wealth of information remains undiscovered.

This interdisciplinary course will delve into the world of AI and its applications for medical images. Students will learn the mathematical tools and concepts of image processing, feature extraction, image registration, segmentation, and classification. We will explore various imaging modalities, from molecular/cellular imaging to tissue/organ imaging, and learn to apply software tools, publicly available image data sources, and deep-learning methods to real-world biomedical applications. Through collaborative research, we will apply AI diagnostic tools to critical problems such as brain tumor segmentation and cell counting in cancer.



Lung cancer cells invade surrounding tissues and start to spread. Image courtesy of the National Cancer Institute.

In the introductory lectures, students will gain an appreciation for the vast array of images and data collected from biomedicine. We will become familiar with common imaging modalities including CT, X-ray, microscopy, ultrasound, and MRI. Students will



An example of a Capstone project emanating from the classification task is to classify normal healthy scans from abnormal CT scans. Image credit: Dmitriy Gutarev via Pixabay.

learn to visualize the intricate details of these images. Through image processing concepts, such as pre-processing techniques like image enhancement, denoising, edge detection, and region growing, students will develop the necessary skills to extract information from the images for analysis. In parallel, hands-on labs will promote collaboration to develop coding skills in image processing and AI. Students also will have an opportunity to explore biomedical image visualization to assess the applications that drive their curiosity and interest. In discussion sections, students will form groups with the help of our TA, and brainstorm research questions related to using AI as a tool in medical imaging. The course projects that emerge from each group's research question will be scaffolded, so that every week groups will perform tasks that will build toward the final presentation—from image visualization to analysis and novel applications.

Further into the course, we will delve into the powerful concepts of deep learning, and students will gain an understanding of the training, testing, and validation pipeline. Feature extraction will cover the crux of computer vision concepts of detection, segmentation, and classification problems related to applications in healthcare. Students will also learn the popular ResNet and UNet deep learning network architectures. These are the most commonly used neural networks for analyzing images. Facial recognition software also uses an algorithm like this! We will learn how these methods can be applied to diagnose and treat diseases. Students will practice these skills in lab and conduct research on their selected project, as well as gain feedback in discussion sections from their TA and mentor.

Towards the end of the course, we will dive into the evaluation of deep learning models, with a focus on case studies and a review of the latest research. In the lab,

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students will gain hands-on experience building deep neural networks using Python packages like TensorFlow or PyTorch to solve real-world biomedicine problems. Additionally, we will have guest lectures from some of the experts in the field. These will be interactive panels where students can learn about cutting-edge research in AI and ask questions about future trends. In discussion sections, our TA will offer support as groups complete their papers and practice their final presentations. The course will conclude with a Capstone Seminar where all students will present their research findings to their peers and invited guests.


Revolutionizing Healthcare: AI can assist doctors for precise prognosis and diagnosis. Image credit: Accuray via Unsplash.

Potential research questions include:

- Is the world ready for integrated AI in healthcare? Do the potential risks outweigh the benefits? If yes, then why? If not, then explore what new AI methods are missing in the state-of-the-art.
- Explore the pros and cons of using AI in healthcare. Describe the advantages of the deep learning methods from the course for biomedical applications and potential improvements.
- What are some of the unique features of biomedical image analysis that distinguish it from natural image processing?
- Develop methods for modeling anomalies in biomedical imaging data.
- Address the challenges of limited and noisy data in low-resource settings.
- Why do we work with anonymized images? How do we address ethical and legal concerns related to the use of biomedical imaging data, such as privacy and informed consent?