CAP 5516
Medical Image Computing
(Spring 2022)

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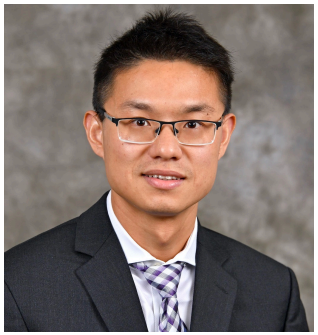
Lecture 1: Course Introduction

About the instructor



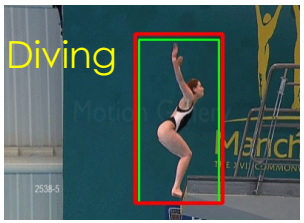
Chen Chen, Ph.D.

Assistant Professor
Center for Research in Computer Vision (CRCV)

Research Interests:
Computer Vision
Machine Learning
Image and Video Processing

https://www.crcv.ucf.edu/chenchen/

Action detection



Red: Our detection Green: Ground Truth

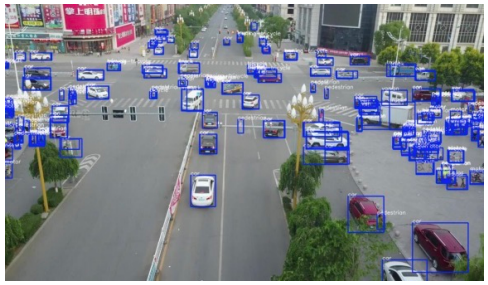
Video object segmentation

ICCV'17 BMVC'19

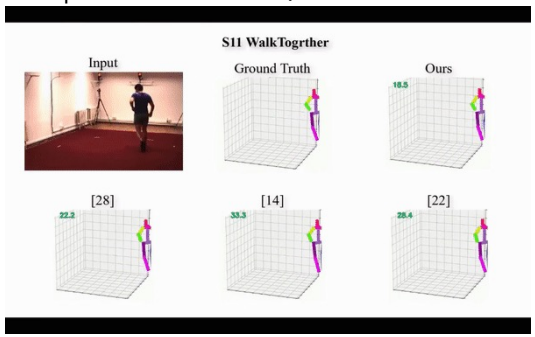
Research Highlight

- Computer Vision
  - *Object detection and tracking*
  - *Action detection and recognition*
  - *Human 2d/3d pose estimation*
  - *Image semantic segmentation*
  - *Image restoration*
- Machine Learning
  - *Efficient deep learning*
  - *Robust machine learning*
  - *Federated learning*

Object detection in aerial images

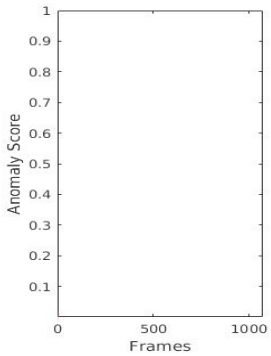


3D pose estimation/reconstruction



CVPR'18,

Video anomaly detection



CVPR'18

Efficient 3D CNN for Real-time Brain Tumor Segmentation (MICCAI Oct. 2019, 61 citations)

- Light-weight and efficient 3D CNN for 3D MRI brain tumor segmentation
  - 3.88M parameters (low memory overhead)
  - Inference time (s) for a single 3D volumetric segmentation
    - 0.019s on one GPU
    - 20.6s on one CPU

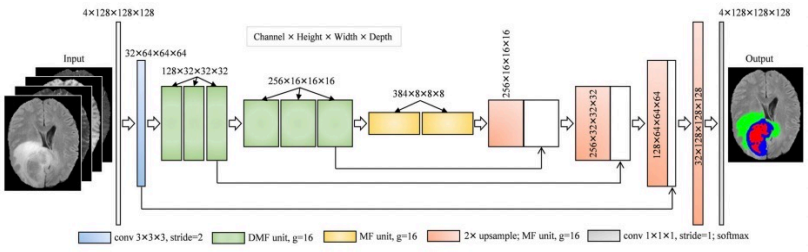
Lower values the better

Higher values the better

Model	Params(M)	FLOPs	Dice_score(%)		
			ET	WT	TC
0.75× MFNet (**ours**)	**1.81**	**13.36**	79.34	90.22	84.25
MFNet (**ours**)	3.19	20.61	79.91	90.43	84.61
DMFNet (**ours**)	3.88	27.04	80.12	90.62	84.54
3D U-Net [1]	16.21	1669.53	75.96	88.53	71.77

BraTS 2018 validation set

Network architecture



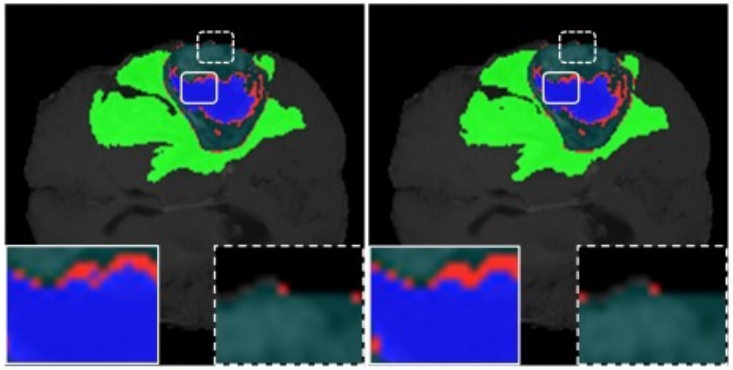
Chen, Chen, Xiaopeng Liu, Meng Ding, Junfeng Zheng, and Jiangyun Li. "3D dilated multi-fiber network for real-time brain tumor segmentation in MRI." In *International Conference on Medical Image Computing and Computer-Assisted Intervention*, pp. 184-192. Springer, Cham, 2019.

TransBTS: Multimodal Brain Tumor Segmentation Using Transformer (MICCAI Sep. 2021, 19 citations)

- First attempt of exploiting Transformer in 3D CNN for 3D MRI Brain Tumor Segmentation
  - Novel network design: incorporating Transformer in 3D CNN to unleash the power of both architectures
  - State-of-the-art performance on two benchmarks: BraTS 2019 and 2020

BraTS 2020 validation set

Method	Dice Score (%) ↑		
	ET	**WT**	**TC**
3D U-Net [6]	68.76	84.11	79.06
Basic V-Net [12]	61.79	84.63	75.26
Deeper V-Net [12]	68.97	86.11	77.90
Residual 3D U-Net	71.63	82.46	76.47
TransBTS w/o TTA	78.50	89.00	81.36
TransBTS w/ TTA	**78.73**	**90.09**	**81.73**

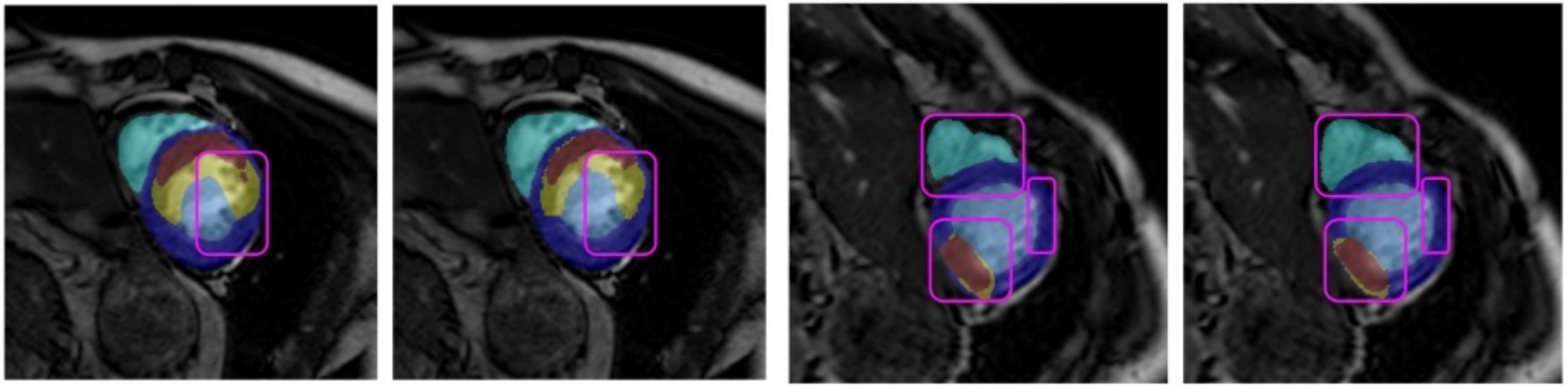


TransBTS **(Ours)** Ground Truth

Wang, Wenxuan, **Chen Chen**, Meng Ding, Hong Yu, Sen Zha, and Jiangyun Li. "Transbts: Multimodal brain tumor segmentation using transformer." In *International Conference on Medical Image Computing and Computer-Assisted Intervention*, pp. 109-119. Springer, Cham, 2021.

Multi-sequence Cardiac MR Images Segmentation (MICCAI 2020 Workshop)

- Task: Myocardial pathology segmentation in cardiac magnetic resonance (CMR)
- Proposed method: Dual Attention U-Net



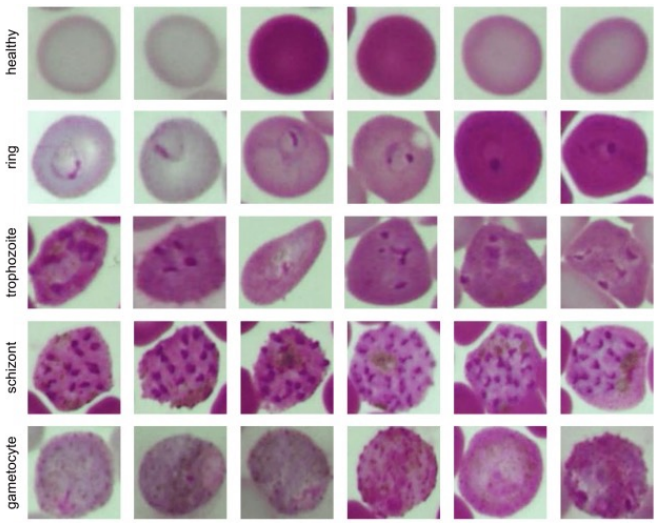
Ours | Ground truth | Ours | Ground truth

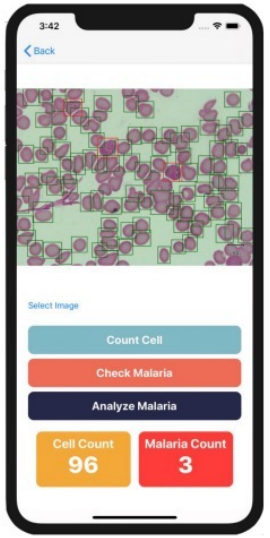
Yu, Hong, Sen Zha, Yubin Huangfu, **Chen Chen**, Meng Ding, and Jiangyun Li. "Dual Attention U-Net for Multi-sequence Cardiac MR Images Segmentation." In Myocardial Pathology Segmentation Combining Multi-Sequence CMR Challenge, pp. 118-127. Springer, Cham, 2020.

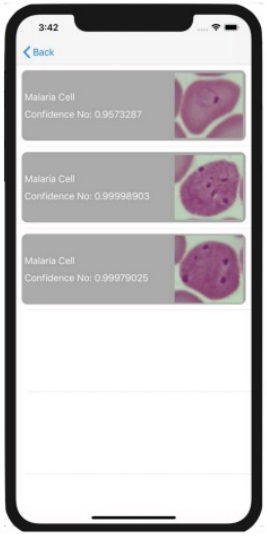
Malaria Life-Cycle Classification in Thin Blood Smear Images

- A new large scale microscopic image malaria dataset
- A two-stage approach for malaria detection and malaria life-cycle-stage classification
- A mobile application

  is developed





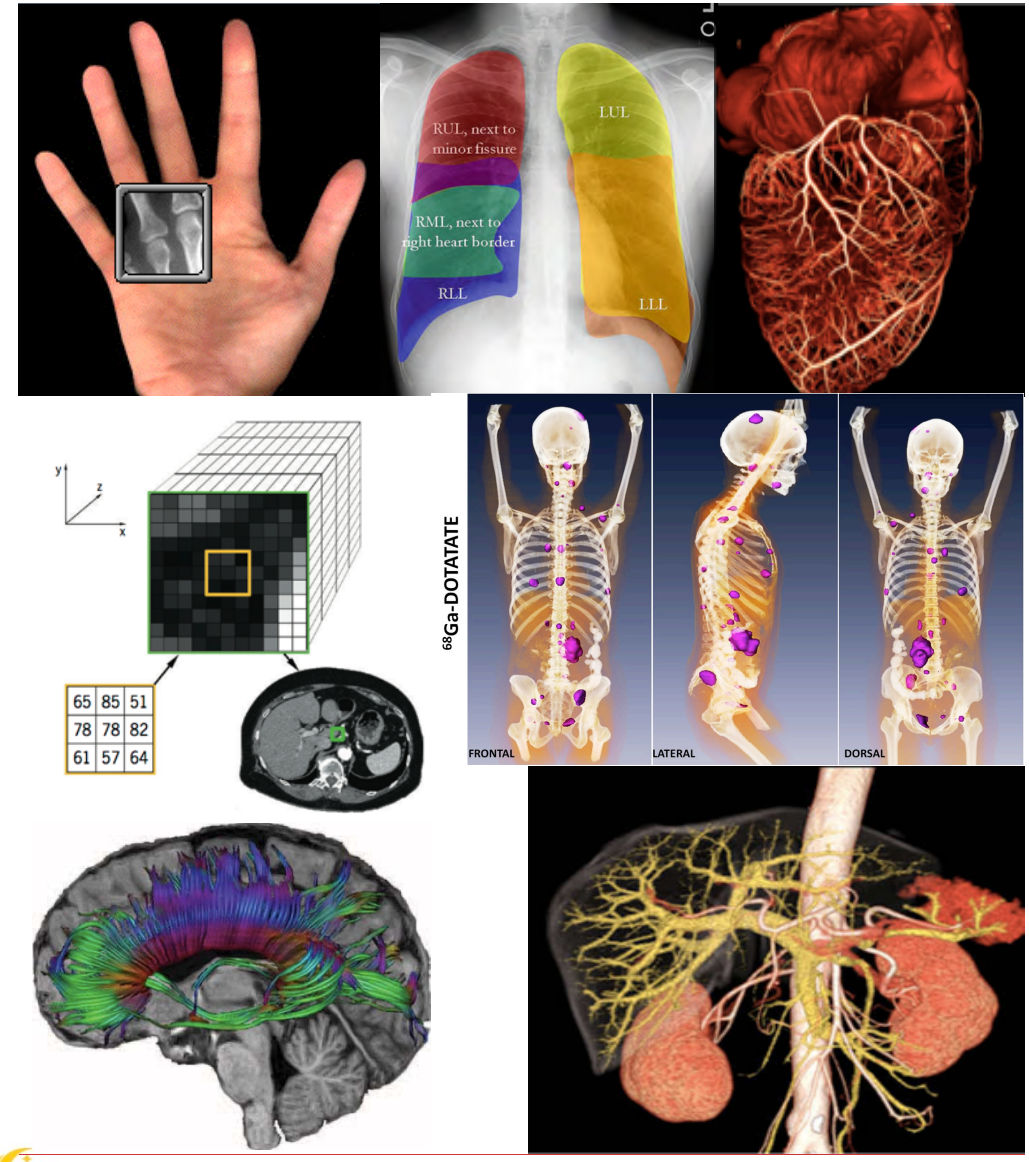


Arshad, Qazi Ammar, Mohsen Ali, Saeed-ul Hassan, **Chen Chen**, Ayisha Imran, Ghulam Rasul, and Waqas Sultani. "A Dataset and Benchmark for Malaria Life-Cycle Classification in Thin Blood Smear Images." Neural Computing and Applications, 2021. preprint available at https://arxiv.org/pdf/2102.08708.pdf

Student Introduction

- Name
- Program: UG, G (MS or PhD)
- Any background knowledge in
  - Image processing
  - Computer vision
  - Deep learning

Logistics



- This is an interdisciplinary course
- **Lectures:** Tuesday and Thursday, 1:30pm-2:45pm
- **Location**: Online via Zoom
- **Office hours (online):** Email me for an appointment

Zoom Link

- Lecture will be recorded and uploaded to Canvas

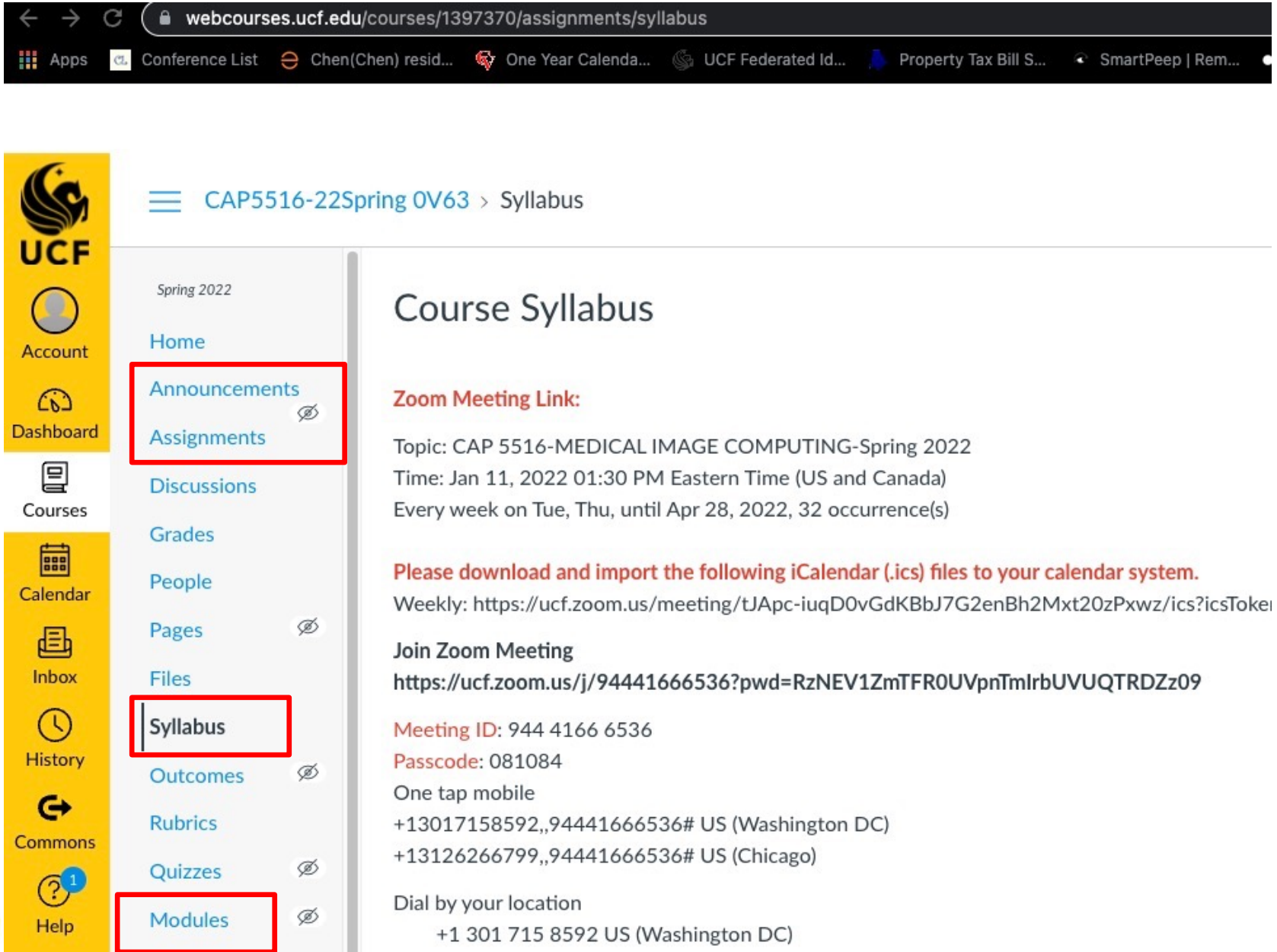
Join Zoom Meeting
https://ucf.zoom.us/j/94441666536?pwd=RzNEV1ZmTFR0UVpnTmlrbUVUQTRDZz09

Meeting ID: 944 4166 6536
Passcode: 081084

Canvas (webcourses@UCF)

- Sending reminders, notifications, etc.
- Post course materials, recorded lecture videos
- Submitting reports and assignments
- Discussions

Canvas (webcourses@UCF)



Syllabus

- Textbook
- Reading materials
- Prerequisites and preparation
- Course requirement
- Grading policy
- Academic integrity
- Statement regarding COVID-19

Textbook

- There is no textbook for this class. We will discuss some of the recent top-quality research papers in the course materials.

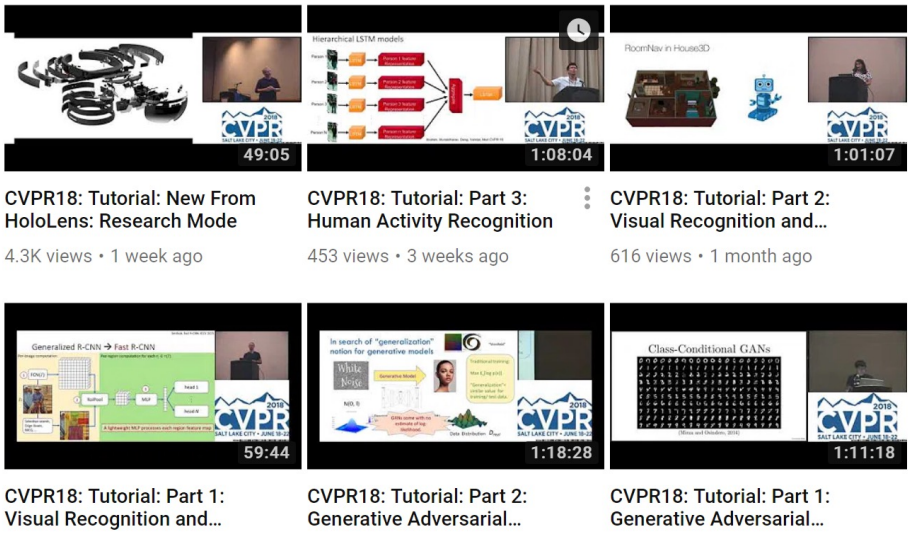
- Recommended supplemental textbook
  - Suetens, P. Fundamentals of Medical Imaging, Cambridge University Press
  - Prince, J. & Links, J. Medical Imaging Signals and Systems, Prentice Hall
  - Bankman, Isaac. Handbook of Medical Imaging: Processing and Analysis, Academic Press
  - Pattern Recognition and Machine Learning, Christopher M. Bishop (2006). "Deep Learning" by Ian Goodfellow, Yoshua Bengio, Aaron Courville (free online: http://www.deeplearningbook.org/
  - Online textbook "Computer Vision: Algorithms and Applications" by Richard Szeliski
  - Introduction to Machine Learning, Ethem Alpaydin (2014), MIT Press. https://www.cmpe.boun.edu.tr/~ethem/i2ml3e/
  - Artificial Intelligence: A Modern Approach, (Third edition) by Stuart Russell and Peter Norvig.

Recommended Resources (1)

- CS231n: Convolutional Neural Networks for Visual Recognition: http://cs231n.stanford.edu
- Theories of Deep Learning (STATS 385): https://stats385.github.io
- CAP5415 – Computer Vision: https://www.crcv.ucf.edu/courses/cap5415-fall-2021/
- Python for Computer Vision: http://programmingcomputervision.com/downloads/ProgrammingComputerVision_CCdraft.pdf

Recommended Resources (2)

- Computer Vision Foundation open access (CVPR, ICCV conference papers over the past years)
- YouTube channel for CVF
  - https://www.youtube.com/channel/UC0n76gicaarsN_Y9YShWwhw/videos



Conferences and Journals to Follow

- The top-tier conferences (double blind, acceptance rates are below 25%, high quality technical articles):
  - MICCAI (medical image computing & computer assisted intervention)
  - IPMI (Information Processing in Medical Imaging)
  - Other conferences: IEEE ISBI, EMBC, ICIP and SPIE Med Imaging
  - Clinical Conferences: RSNA (>65.000 attendances), ISMRM, SNM
    - Vision and ML conferences: CVPR, NeurIPS, ICML, ICLR, ECCV, ICCV
- The top-tier technical journals:
  - IEEE TMI, TBME, PAMI, and TIP
  - Medical Image Analysis, CMIG, and NeuroImage
- The top-tier clinical journals relevant to MIC:
  - Radiology, Journal of Nuclear Medicine, AJR, Nature Methods, Nature Medicine, PlosOne, Radiology AI, …
- ArXiv, BioRxiv…

Prerequisites and Preparation

- Recommended preparation: basic probability, statistics, linear algebra, calculus, optimization.
  - CS231n: Convolutional Neural Networks for Visual Recognition: http://cs231n.stanford.edu
  - CAP5415 – Computer Vision: https://www.crcv.ucf.edu/courses/cap5415-fall-2021/
- Proficient in programming languages (e.g., Python).
  - Programming Computer Vision with Python: http://programmingcomputervision.com/downloads/ProgrammingComputerVision_CCdraft.pdf
- General knowledge of deep learning frameworks: PyTorch, TensorFlow, Keras, etc.
  - PyTorch tutorial
    - https://web.stanford.edu/class/cs224n/materials/CS224N_PyTorch_Tutorial.html
    - http://cs231n.stanford.edu/slides/2021/discussion_4_pytorch.pdf
    - https://youtu.be/BL6uJxZB2TA
    - https://youtu.be/36EMl6DEvbk

Programming Resources

- **M**edical **O**pen **N**etwork for **AI**
  - MONAI is a PyTorch-based, open-source framework for deep learning in healthcare imaging, part of PyTorch Ecosystem.
  - GitHub page: https://github.com/Project-MONAI/MONAI
  - MONAI modules overview: https://docs.monai.io/en/latest/highlights.html#datasets-and-dataloader
  - MONAI tutorials and medical image analysis examples: https://github.com/Project-MONAI/tutorials
  - **[Video Tutorial]** PyTorch and Monai for AI Healthcare Imaging - Python Machine Learning Course: https://www.youtube.com/watch?v=M3ZWfamWrBM&t=16429s

Course Requirements

- Reading research papers and writing review reports
- Class participation
  - All students are expected to take part in class discussions, e.g., asking questions about the paper.
- Presentation
  - Each student will present one paper during the semester. A list of papers will be provided covering a range of topics.
- Programming assignments
  - Three programming assignments (deep learning-based image classification, image segmentation, image synthesis (GANs))
- Research project
  - Students will complete an individual research project (must be deep learning related) on a topic relevant to the course.
  - A list of project ideas will be provided.

Grading Policy

- Reports (10 paper reviews) 20%
- Paper Presentation 15%
- Attendance and Discussion 5%
- Programming Assignments (3) 30%
- Final Project 30%

- **Late policy**
  - **No late report/assignment is allowed.**
  - **Submit report/assignment in webcourses.**

- Letter Grade
  - 95-100 = A 90-94 = A- 85-89 = B+ 80-84 = B 75-79 = B- 70-74 = C+ 65-69 = C 60-64 = C- 55-59 = D+ 50-54 = D 45-49 = D- 0-44 = F

Final Project

- Project proposal
- Milestone report
- Final report and project presentation

Computing Resources

- Google Colab
  - Google Colab tutorial: https://speech.ee.ntu.edu.tw/~hylee/ml/ml2021-course-data/hw/Colab/Google_Colab_Tutorial.pdf
- Kaggle
  - How to use FREE GPU & TPU on Kaggle

  https://www.youtube.com/watch?v=1QXdUWfipx0
  https://www.kaggle.com/dansbecker/running-kaggle-kernels-with-a-gpu
  https://www.youtube.com/watch?v=u9pIhOay8Fw
- UCF Newton GPU cluster
  - https://arcc.ist.ucf.edu/index.php/resources/newton/about-newton
  - User registration request: https://arcc.ist.ucf.edu/index.php/accounts/user-registration
  - UCF HPC GPU Accounts presentation by Dr. R. Paul Wiegand
    - https://www.crcv.ucf.edu/wp-content/uploads/2020/01/Wiegand-SP2020-CAP6412overview.pdf
    - Video: https://www.crcv.ucf.edu/wp-content/uploads/2019/03/Lecture-4.mp4

Academic Integrity

- Students should familiarize themselves with UCF's Rules of Conduct at <https://scai.sdes.ucf.edu/student-rules-of-conduct/Links to an external site.>. According to Section 1, "Academic Misconduct," students are prohibited from engaging in
- Unauthorized assistance: Using or attempting to use unauthorized materials, information or study aids in any academic exercise unless specifically authorized by the instructor of record. The unauthorized possession of examination or course-related material also constitutes cheating.
- Communication to another through written, visual, electronic, or oral means: The presentation of material which has not been studied or learned, but rather was obtained through someone else's efforts and used as part of an examination, course assignment, or project.
- Commercial Use of Academic Material: Selling of course material to another person, student, and/or uploading course material to a third-party vendor without authorization or without the express written permission of the university and the instructor. Course materials include but are not limited to class notes, Instructor's PowerPoints, course syllabi, tests, quizzes, labs, instruction sheets, homework, study guides, handouts, etc.
- Falsifying or misrepresenting the student's own academic work.
- Plagiarism: Using or appropriating another's work without any indication of the source, thereby attempting to convey the impression that such work is the student's own.
- Multiple Submissions: Submitting the same academic work for credit more than once without the express written permission of the instructor.
- Helping another violate academic behavior standards.
- Soliciting assistance with academic coursework and/or degree requirements.

General Statement Regarding COVID-19

- I recognize and understand the difficult times we are all in. The COVID-19 pandemic impacts us all in many ways, including physically, mentally, emotionally, financially, academically, and professionally. I will work with you on challenges you may be encountering and to provide support to help you succeed. However, please keep in mind that I will hold you accountable, especially in terms of class attendance, participation, and contributions.

Course Structure

- Lectures
  - Cover a few key and trending topics for medical image computing
    - Medical image processing (basics and fundamentals)
    - Introduction to deep learning (CNNs, Vision Transformer)
    - Medical image classification and segmentation (deep learning methods)
    - GANs and their applications in medical image analysis
    - Self-supervised learning for medical image computing
    - Adversarial learning, robustness of deep learning models for medical image computing
    - Data privacy and federated learning for medical image computing
- Paper presentations
- Final project presentations

Course Outcomes

- Outcomes
  - Understand the basics of medical image computing and know the state-of-the-art techniques for medical image analysis (lectures and paper reviews)
  - Hands-on experiences on solving medical image computing problems (programming assignments and course project)
  - Develop skills for conducting research (paper reviews, paper presentation, project presentation and reports)

Motivation

- Imaging sciences is experiencing a tremendous growth in the U.S. The NYT recently ranked biomedical jobs as the number one fastest growing career field in the nation and listed bio-medical imaging as the primary reason for the growth.

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- Biomedical imaging and its analysis are fundamental to (1) understanding, (2) visualizing, and (3) quantifying information.

Motivation

- Imaging sciences is experiencing a tremendous growth in the U.S. The NYT recently ranked biomedical jobs as the number one fastest growing career field in the nation and listed bio-medical imaging as the primary reason for the growth.
- Biomedical imaging and its analysis are fundamental to (1) understanding, (2) visualizing, and (3) quantifying information.
- This course will mostly focus on analysis of biomedical images with deep learning-based methods.

Homework 0

- Paper selection for presentation

Thank you!

Question?

References and Slide Credits

- Some of the slides are adapted from Dr. Ulas Bagci's course materials