



Fundamentals of Medical Imaging

郑锐 Zheng Rui (助理教授/研究员)

上海科技大学信息科学与技术学院

E-mail: zhengrui@shanghaitech.edu.cn

地址：信息学院大楼2号楼302.G

Information

Time: Monday & Wednesday, 3:00-4:40 pm,
Week 1-16,

Location: 信息学院1B-110

Teacher: 郑锐

Email: zhengrui@shanghaitech.edu.cn

Office: 信息学院2号楼302.G

Tel: 20684452

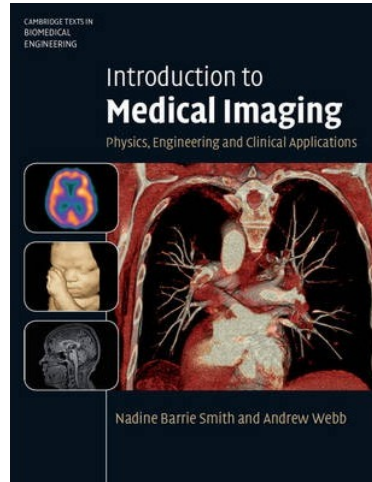
TA : 葛嵩瀚

Email: gesonghan@shanghaitech.edu.cn



群名称:2020秋季学期医学影像学课...
群 号:1038098738

Textbook

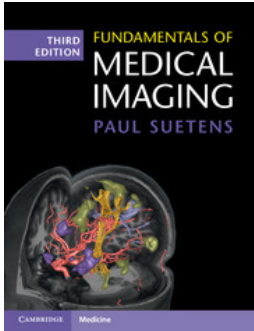


Introduction to Medical Imaging: Physics, Engineering and Clinical Applications

AUTHOR: Nadine Barrie Smith & Andrew Webb

PUBLISHER: Cambridge University Press (2010)

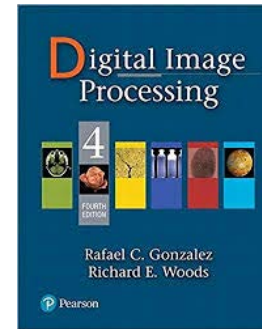
Reference book



Fundamentals of Medical Imaging, 3rd Edition

AUTHOR: Paul Suetens

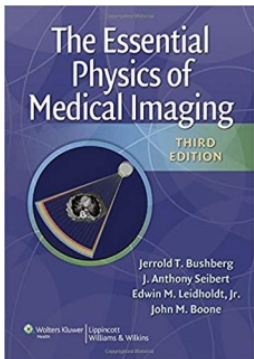
PUBLISHER: Cambridge University Press (2017).



Digital Image Processing, 4th edition

AUTHORS: Rafael C. Gonzalez & Richard E. Woods

PUBLISHER: Pearson (2017)



The Essential Physics of Medical Imaging, 3rd Edition

AUTHORS: Bushberg J. T., Seibert J. A., Leidholdt E. M. Jr., Boone J. M

PUBLISHER: Lippincott Williams & Wilkins (2011)



医学影像成像理论（第二版）

作者: 李月卿

出版社: 人民卫生出版社 (2010)

Schedule

Week	Date	Topic	Reading Material	Homework
1	9月7日	Introducton to Medical imaging		Due: 9/21
	9月9日	Image characteristics	CH1.1-1.9	
2	9月14日	Basics of Digital image processing	DIP CH2.4, CH2.6	
	9月16日	X-ray physics, Radioactivity	CH2.1-2.5	Due: 10/10
3	9月21日	Instrumentation and Characteristics of Radiography	CH2.6-2.8	
	9月23日	X-ray Imaging application	CH2.9-2.11	
4	9月28日	Image Reconstruction Algorithm	CH2.14, DIP CH5.11	
	9月30日	CT Instrumentation	CH2.12-2.13, 2.15	
5	10月5日	Clinical application of CT	CH2.16-2.18	
	10月7日			
6	10月12日	Midterm 1 / invited talk		Due: 11/2
	10月14日	Introduction to Nuclear Medicine	CH3.1-3.5	
7	10月19日	Gamma Camera	CH3.6	
	10月21日	SPECT, Image characteristics	CH3.7-3.9	
8	10月26日	PET/CT	CH3.13-3.21	
	10月28日	Radiation Biology and protection		Due: 11/14
9	11月2日	Ultrasound Physics	CH4.1-4.4	
	11月4日	Ultrasound Instrumentation	CH4.5-4.7	
10	11月9日	Ultrasound Image Characteristics	CH4.8-4.10	
	11月11日	Applcation of Ultrasound	CH4.11	Due: 12/9
11	11月16日	Midterm 2 / invited talk		
	11月18日	Magnetic resonance	CH5.1-5.4	
12	11月23日	Relaxation time	CH5.5-5.7	
	11月25日	MRI Image Acquistion	CH5.8-5.10	
13	11月30日	MRI sequence	CH5.11-5.13	
	12月2日	MRI Instrumenation	CH5.14-5.16	
14	12月7日	Image Characteristics and Applcation of MRI	CH5.17-5.23	
	12月9日	Medical image computing & visualization	FMI CH7-8	
15	12月14日	Midterm 3 / invited talk		
	12月16日	TBD		
16	12月21日	Project presentation		
	12月23日			

Assessment

➤ Homework (30%)

- 5 assignments (1st-4th : 5%, 5th: 10%) ;
- Handwriting or Hard copy;
- Only half score is counted if not submitting before due date; No score if not submitting at all.

➤ Quiz (5%): missing twice -2%; missing more than twice : -5%

➤ Midterm Exam (30%) : 3 times, 10% for each;

➤ Project (35%)

- Content: **Literature review on a specific subject related to medical imaging;**
- Group of maximum 2 persons
- Group presentation: PPT in English, present in Chinese or English.
- Individual project report (English) : in the format of IEEE transaction, minimum 3000 words and 20 references; everyone should submit the report independently.
- Score requirement (以100分计)
 - ✓ Presentation (30分): 思路清晰, 重点明确, 按时完成;
 - ✓ Q&A (10分) : 正确回答问题, 条理清楚;
 - ✓ Report (60分) : 问题阐述明确, 内容完整, 逻辑通顺, 格式正确;
 - ✓ Submission package: PPT and Report;
 - ✓ 截止时间: Abstract (optional, before Nov. 22nd), Final package (12月27日)。无特殊情况逾期, 24小时内扣20%分, 24小时以外扣除50%分, 未交则该project计0分。

COVID-19

2月12日，湖北新增确诊14840例，激增背后的原因是什么？

“尽管其他的病毒性或细菌性肺炎的CT 影像与新型冠状病毒肺炎尽早隔离治疗也是首选”，张玉蛟说，“如果怀疑并发细菌感染的抗生素。CT 检测的优势是立竿见影，马上可以做出判断。对直观的影像资料。”

最后，张玉蛟也提醒CT存在的三点局限性：一是与其它肺部期感染可能没有明显的肺部影像改变；三是影像诊断标准有待进何诊断手段是完美无缺的。”她表示。



新增确诊
病例对比

现有确诊
病例对比

病死率
对比

治愈率
对比

最新《新型冠状病毒肺炎诊疗方案》出炉，为何增加的湖北临床诊断病例又取消了

2020-02-20 13:32:02

长江日报-长江网2月19日讯（记者刘睿彻 通讯员冯霞）19日，国家卫健委发布了最新的《新型冠状病毒肺炎诊疗方案（试行第六版）》，和湖北相关的一项重要变化是，原本在第五版中增加的湖北临床诊断病例又被取消了。原因何在？

华中科技大学同济医学院医药卫生管理学院院长冯占春教授表示，这与临床遵循直接证据作为金标准，核酸检测能力提升，原有病人存量消化等几方面原因有关。

据悉，在第五版的诊疗方案中，湖北以外其他省份仍然分为“疑似病例”和“确诊病例”两类，湖北省增加“临床诊断”分类。湖北的疑似病例只要具有肺炎影像学特征者，就为临床诊断病例。也就是说，疑似病例的CT显示符合新冠肺炎的表现，在没有核酸检测的情况下，就是临床诊断病例。

而临床诊断病例参照确诊病例治疗。12日，湖北省首次公布临床诊断病例，1天之后，就将临床诊断病例纳入确诊病例统计，截至12日，武汉新增确诊病例一天陡增了1.3万人。

冯占春教授介绍，从目前诊断来说，病原学的核酸检测或者基因测序，仍然是诊断病毒感染的金标准，是最直接的证据；而影像学是根据影像如拍CT片做出的临床判断，严格来说，还不是确诊标准。

钟南山院士团队对1099例确诊患者回溯研究发现，仅靠肺部CT确诊新型冠状病毒感染准确率只有76.4%，可见也不能完全迷信CT。如果把CT检查、核酸试剂盒和临床症状结合在一起，确诊的准确率能达到97%。

王嘉兴/中国青年

有检测资质的机
影响防控大局。

佳”。仅仅靠CT
紧，“宁可错杀
方法去救治。

们检查的目的是
？还是为了确定

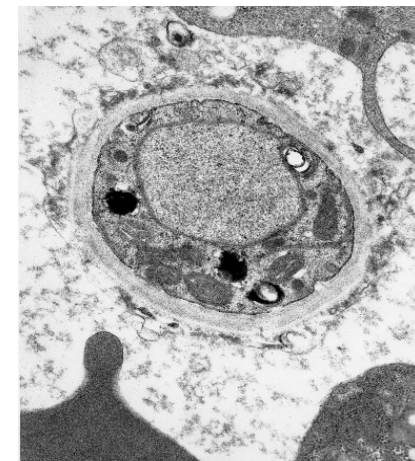
Lecture 1 - Introduction

This lecture will cover:

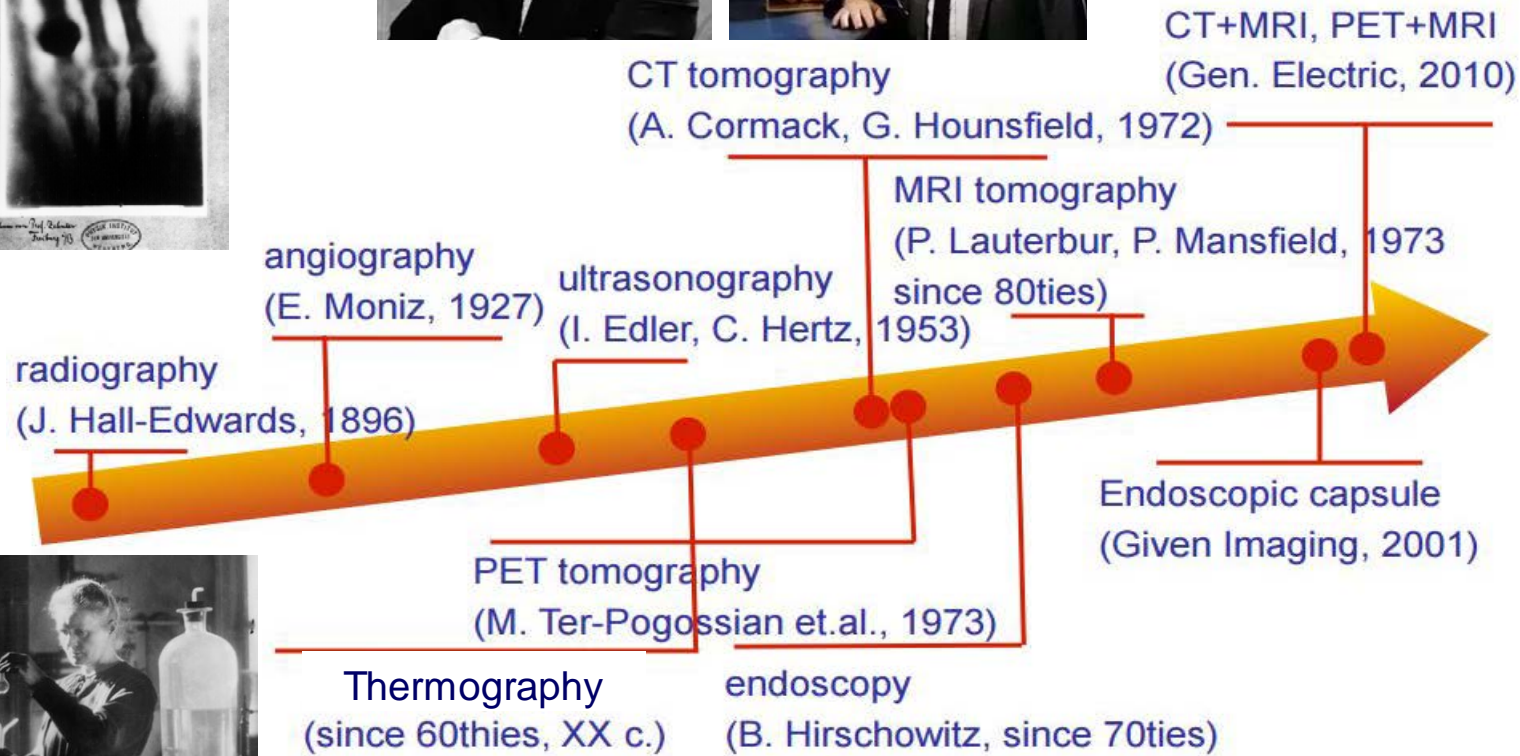
- What is Medical Imaging?
- History of Medical Imaging
- Medical Imaging Modalities
- Contents of the course
- Fundamentals of medical diagnosis

Medical Imaging

- **Medical visual representation of human in multi-modality and multi-dimension**
 - Revealing internal structures of a body (anatomy)
 - Visual representation of the function of some organs or tissues (physiology).
- **Goals**
 - Clinical analysis (Diagnosis)
 - Medical intervention (Treatment)
 - Establishing a database of normal anatomy and physiology to make it possible to identify abnormalities.



History



Categories

- **Imaging content**

- **Biomedical micro-imaging**

- ✓ Scanning Electron Microscope (SEM)
 - ✓ Optical microscope

- **Medical imaging**

- ✓ **Radioactive:** X ray, CT, Nuclear medicine, PET, SPECT
 - ✓ **Non-radioactive:** MRI, Ultrasound, Thermography, Photoacoustic

- **Functional and Anatomical**

Comparison of Imaging modalities

Imaging modalities	2D	3D	Other technology
X-ray	Planar radiography	CT	Angiography, fluoroscopy,
Nuclear medicine	Gamma camera	SPECT, PET/TOF PET	
MRI		MRI	fMRI
Ultrasound	B-mode, M-mode,	Multi-dimension arrays	Doppler ultrasound

Content

➤ What we will learn?

- ✓ Imaging physics and theory
- ✓ Imaging instrumentation
- ✓ Imaging characteristics
- ✓ Application of different image modalities

➤ What we won't learn

- ✗ Electronic signal acquisition --- 电路基础, 模拟数字电路
- ✗ Signal processing --- 信号与系统, 数字信号处理
- ✗ Image analysis --- 数字图像处理、计算机图形学、计算机视觉、机器学习、深度学习
- ✗ Medical diagnosis

Knowledge & Requirement

➤ Involved knowledge

- Physics
- Mathematics
- System and signals analysis
- Anatomy and Physiology

➤ Learning outcome

- Understanding the principles of various medical imaging techniques.
- Computing parameters for each imaging modality such as resolution, signal to noise ratio.
- Evaluating data sets from different devices
- Evaluating and analyzing image properties
- Discussing how a specific imaging modality can relate to an imaging scenario in the body.
- Quality control and Health protection

Fundamentals

- **Diagnostic Test** (*Reference: CH1.2*)
 - Binary Classification
 - Sensitivity and Specificity
 - ROC Curve
- **Anatomical Planes**

Binary Classification (二元分类)

		True Condition (真实值)	
		Positive (阳性)	Negative (阴性)
Predicted Condition (预测值)	Positive (阳性)	True Positive (TP) 真阳性	False Positive (FP) 伪阳性
	Negative (阴性)	False Negative (FN) 伪阴性	True Negative (TN) 真阴性

Contingency Table (列联表)

		True condition			
Total population		Condition positive	Condition negative	Prevalence = $\frac{\Sigma \text{Condition positive}}{\Sigma \text{Total population}}$	Accuracy (ACC) = $\frac{\Sigma \text{True positive} + \Sigma \text{True negative}}{\Sigma \text{Total population}}$
Predicted condition	Predicted condition positive	True positive , Power	False positive , Type I error	Positive predictive value (PPV), Precision = $\frac{\Sigma \text{True positive}}{\Sigma \text{Predicted condition positive}}$	False discovery rate (FDR) = $\frac{\Sigma \text{False positive}}{\Sigma \text{Predicted condition positive}}$
	Predicted condition negative	False negative , Type II error	True negative	False omission rate (FOR) = $\frac{\Sigma \text{False negative}}{\Sigma \text{Predicted condition negative}}$	Negative predictive value (NPV) = $\frac{\Sigma \text{True negative}}{\Sigma \text{Predicted condition negative}}$
		True positive rate (TPR), Recall, Sensitivity, probability of detection $= \frac{\Sigma \text{True positive}}{\Sigma \text{Condition positive}}$	False positive rate (FPR), Fall-out, probability of false alarm $= \frac{\Sigma \text{False positive}}{\Sigma \text{Condition negative}}$	Positive likelihood ratio (LR+) $= \frac{\text{TPR}}{\text{FPR}}$	Diagnostic odds ratio (DOR) $= \frac{\text{LR+}}{\text{LR-}}$ $F_1 \text{ score} = \frac{1}{\frac{1}{\text{Recall}} + \frac{1}{\text{Precision}}}$
		False negative rate (FNR), Miss rate $= \frac{\Sigma \text{False negative}}{\Sigma \text{Condition positive}}$	Specificity (SPC), Selectivity, True negative rate (TNR) $= \frac{\Sigma \text{True negative}}{\Sigma \text{Condition negative}}$	Negative likelihood ratio (LR-) $= \frac{\text{FNR}}{\text{TNR}}$	

Sensitivity and Specificity

- **Sensitivity (敏感性) or True Positive Rate**

$$\text{Sensitivity} = \frac{TP}{TP + FN}$$

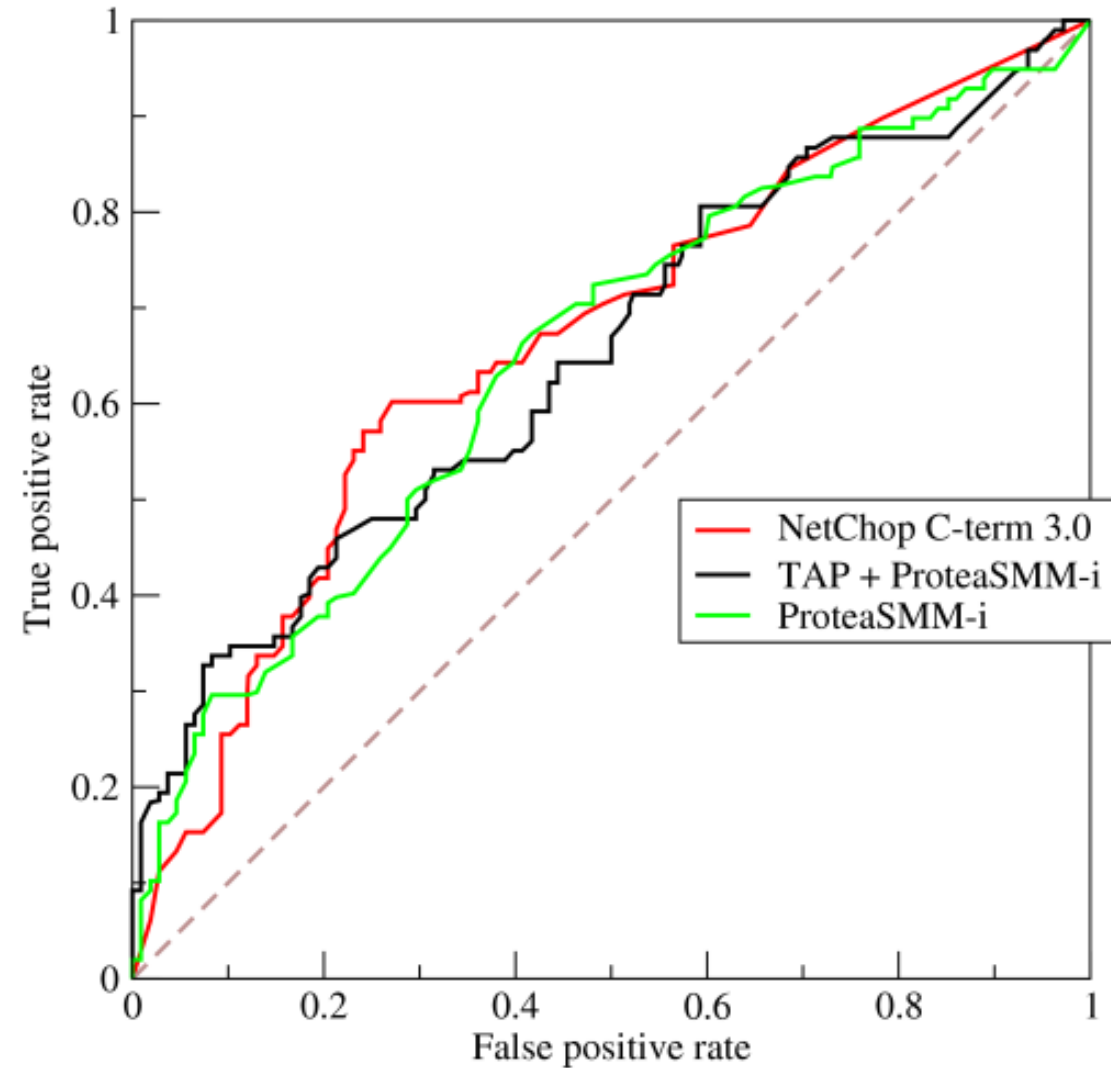
- **Specificity (特异性) or True Negative Rate**

$$\text{Specificity} = \frac{TN}{TN + FP}$$

ROC Curve

Receiver Operating Characteristic (ROC) Curve

(受试者操作特性
曲线)



Anatomical Planes

