Medical Image Analysis

1. Introduction to medical image analysis

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Oct., 2020

https://www.edwith.org/medical-20200327/joinLectures/30437

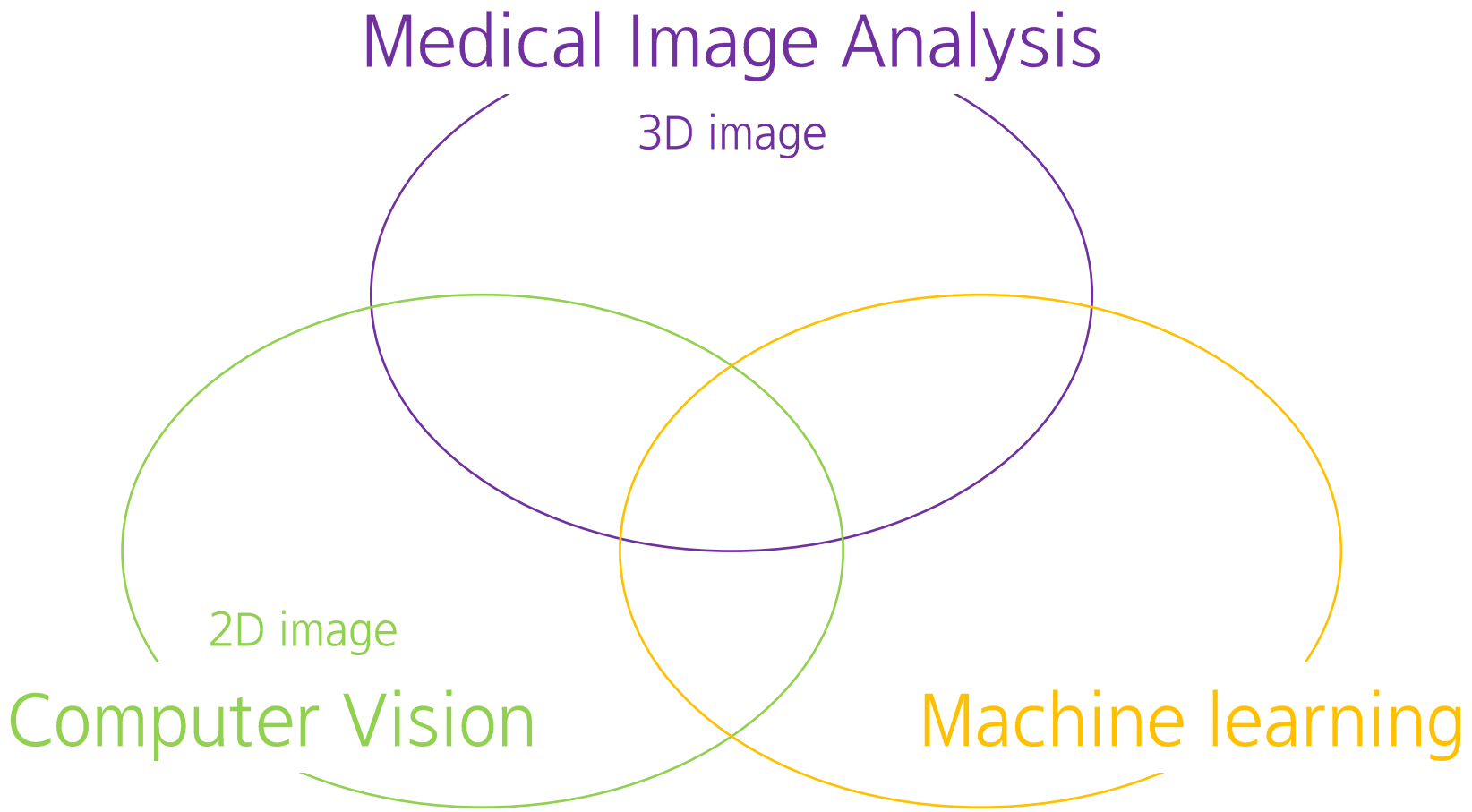
1. Overview

배울 내용

- 의료영상 배경지식
- 의료영상 저장 방식
- MRI, CT의 원리와 특징

1. Overview

Medical Image Analysis



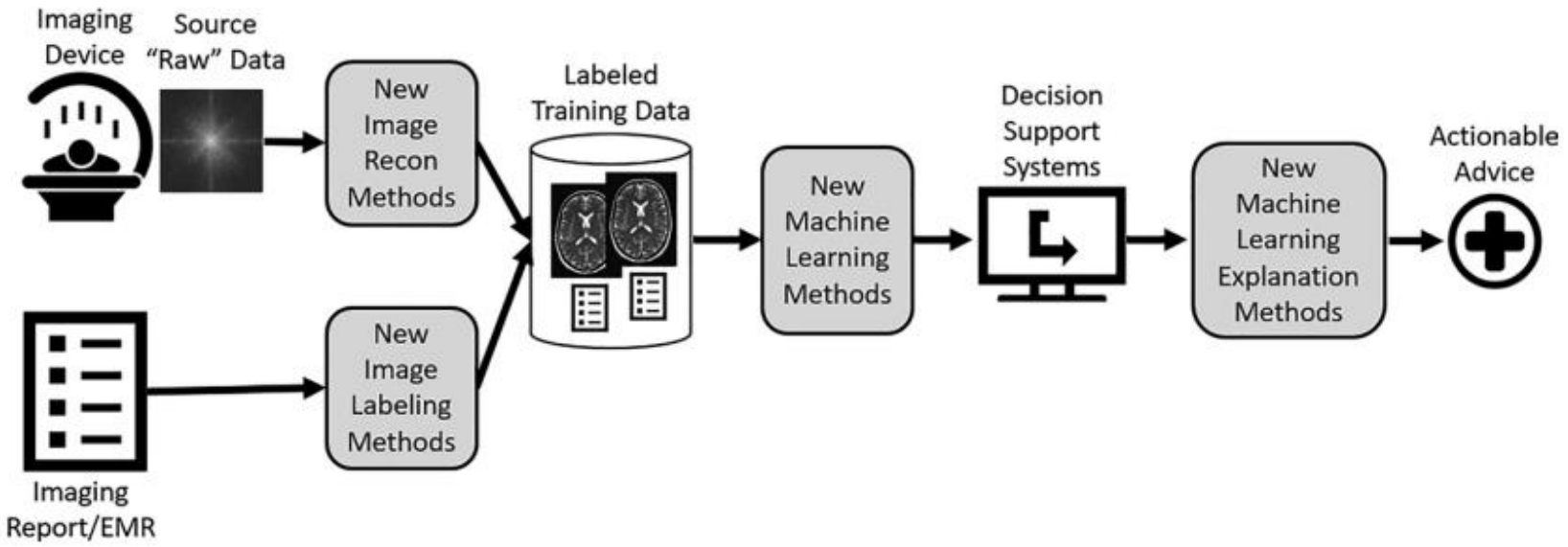
1. Overview

다룰 내용

- Classification
- Segmentation
- Enhancement
- Registration

2.Introduction to medical image analysis 1

Opportunities for AI in medical imaging research

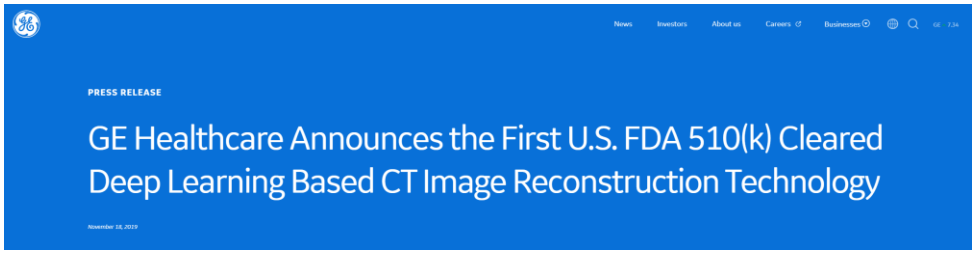


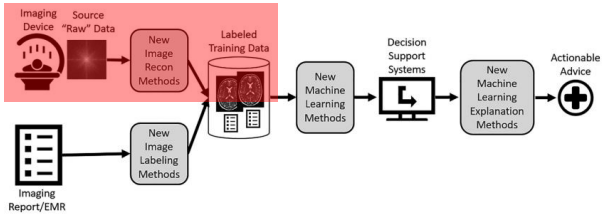
https://pubs.rsna.org/doi/pdf/10.1148/radiol.2019190613

2.Introduction to medical image analysis 1

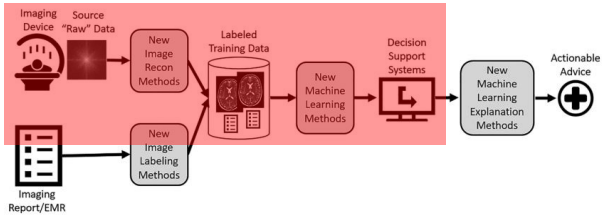
Research examples

- (GE) Healthcare's deep learning-based image reconstruction engine gained FDA clearance
  - 딥러닝 기반으로 방사선 양을 줄이면서도 이미지 성능을 높인 CT 영상 – FDA 승인 (2019. 04)





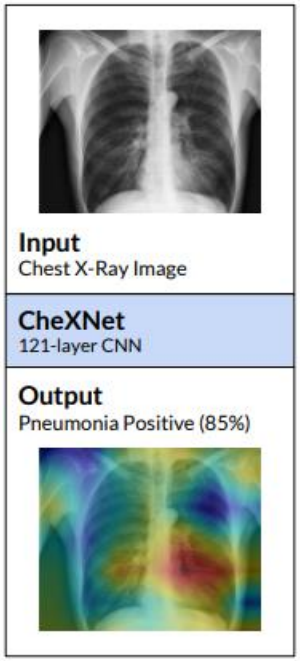
- (Philips) FDA clearance to market Philips IntelliSite Pathology Solution for primary diagnostic use in the US
  - 현미경 이미지를 디지털화 – FDA 승인 (2017. 04)

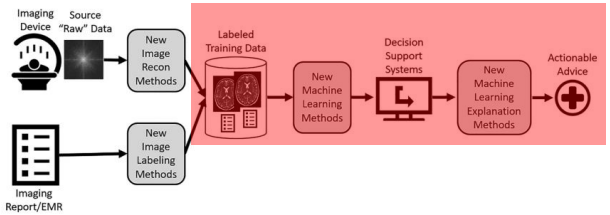


2.Introduction to medical image analysis 1

Research examples

- CheXNet: Radiologist-Level Pneumonia Detection on Chest X-Rays with Deep Learning (2017)
  - X-ray 기반으로 의료질환 발견





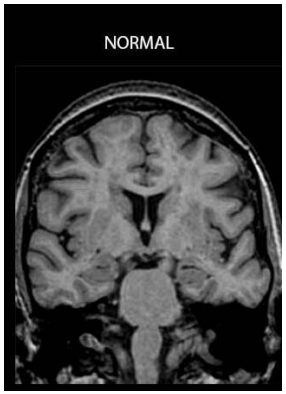
https://arxiv.org/pdf/1711.05225.pdf

3.Introduction to medical image analysis 2

Sub-categories ~ related to computer vision

- Classification
  - 개 VS 고양이
  - 일반인 VS 알츠하이머

VS

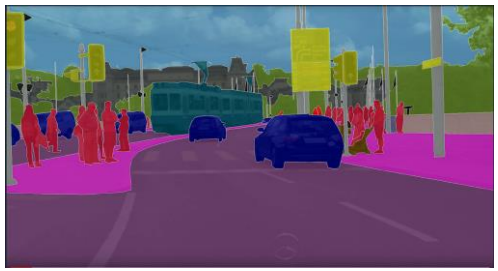


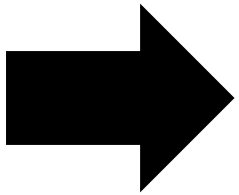
VS

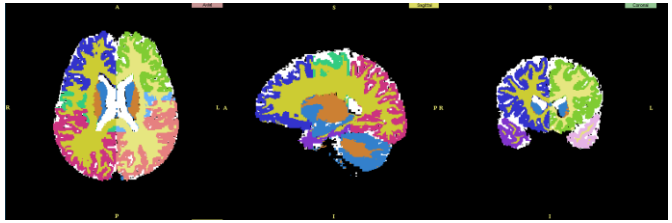
3.Introduction to medical image analysis 2

Sub-categories ~ related to computer vision

- Segmentation
  - 영상 분할



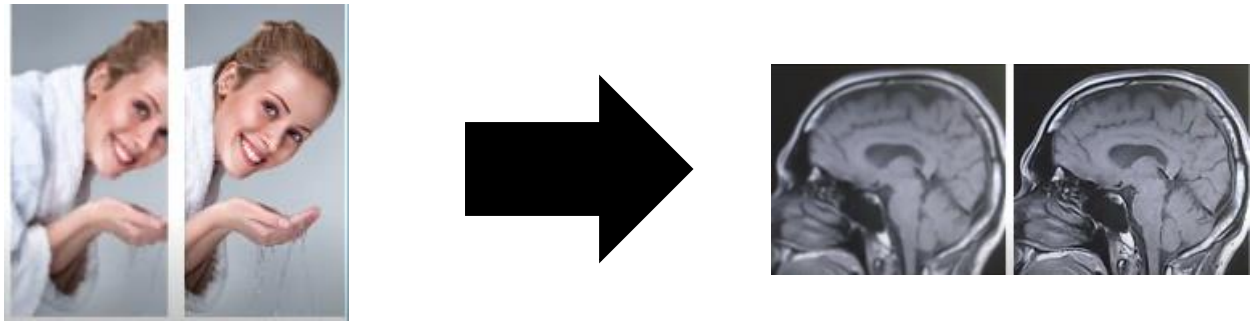




3.Introduction to medical image analysis 2

Sub-categories ~ related to computer vision

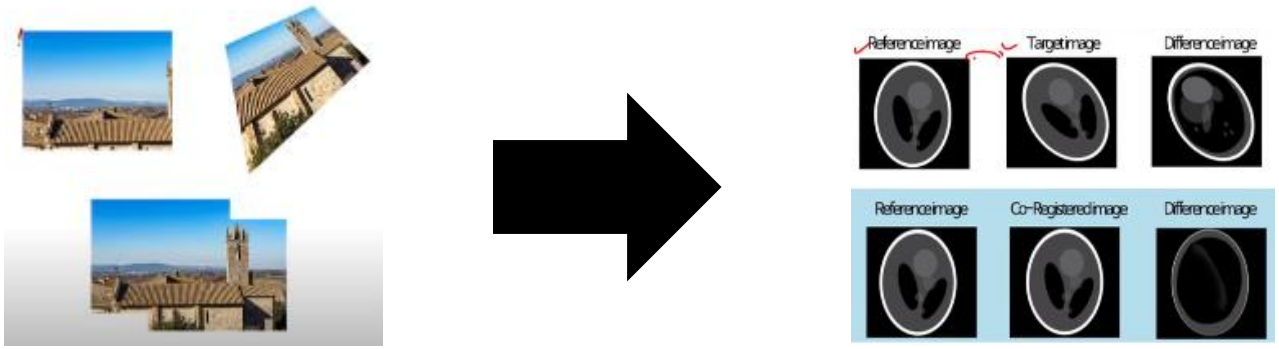
- Enhancement
  - Super resolution



3.Introduction to medical image analysis 2

Sub-categories ~ related to computer vision

- Registration



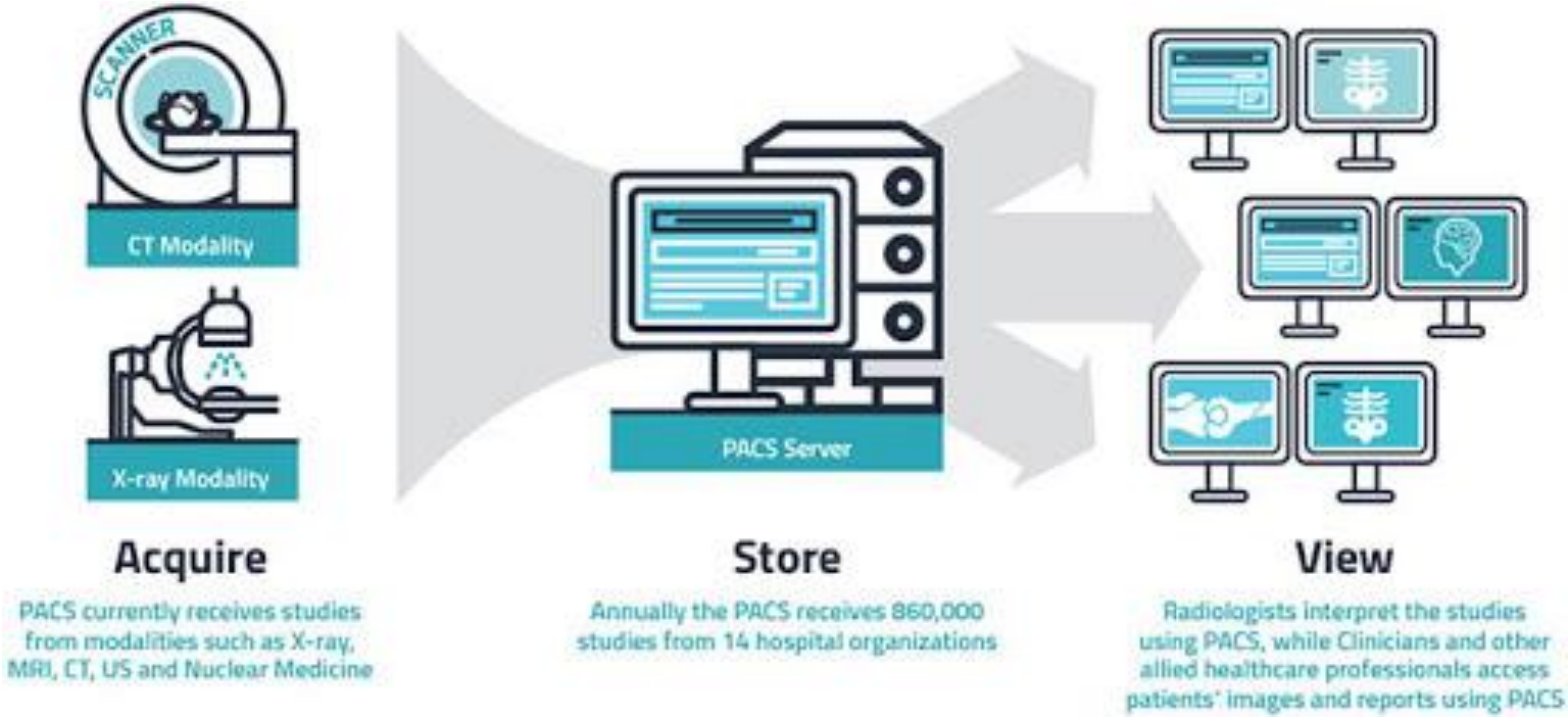
3.Introduction to medical image analysis 2

Contents

Sub-category	Conventional methods	Deep learning methods
Classification	Logistic regression Neural network Support vector machine Random forest	Deep neural network Convolutional neural network
Segmentation	Thresholding Region growing Graph cut Active contour model Active shape model	FCN U-Net DeepLab
Enhancement	Normalization Histogram equalization Filtering Dictionary learning	SRCNN GAN SRGAN
Registration	Transformation matrix Iterative closest point (ICP) Non rigid ICP Deformable models	

4.PACS/DICOM/Visualization

Picture Archiving and Communication System



4.PACS/DICOM/Visualization

DICOM (Digital Imaging and Communications in Medicine)

- International standard for medical images (RSNA)
- Formats of medical images with clinical information
- Other medical image formats
  - Dicom (*.dcm) – 헤더+영상
  - Analyze (*.hdr/*.img) – 헤더/영상
  - Raw data (*.mhd/*.raw) – 헤더/영상
  - Nifti (*.nii/*.nii.gz) – 헤더+영상

4.PACS/DICOM/Visualization

Header information

- Dimension (이미지 크기)
  - e.g. X=256, y=256, z=128
- Voxel spacing (voxel 크기)
  - e.g. X=0.5mm, y=0.5mm, z=1.0mm
- Origin
  - e.g. X=0, y=0, z=0

4.PACS/DICOM/Visualization

Visualization tools

- ITK-SNAP
- 3D Slicer
- ImageJ
- QuPath

ITK-SNAP

5.Image acquisition

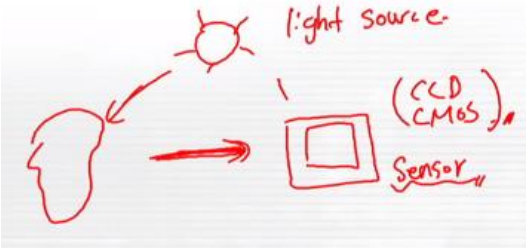
Medical Imaging

- Endoscopy (내시경)
- Microscopy
- X-ray
- Computed Tomography (CT)
- Positron Emission Tomography (PET)
- Magnetic Resonance Imaging (MRI)
- Ultrasound
- Optimal Coherence Tomography (OCT)

5.Image acquisition

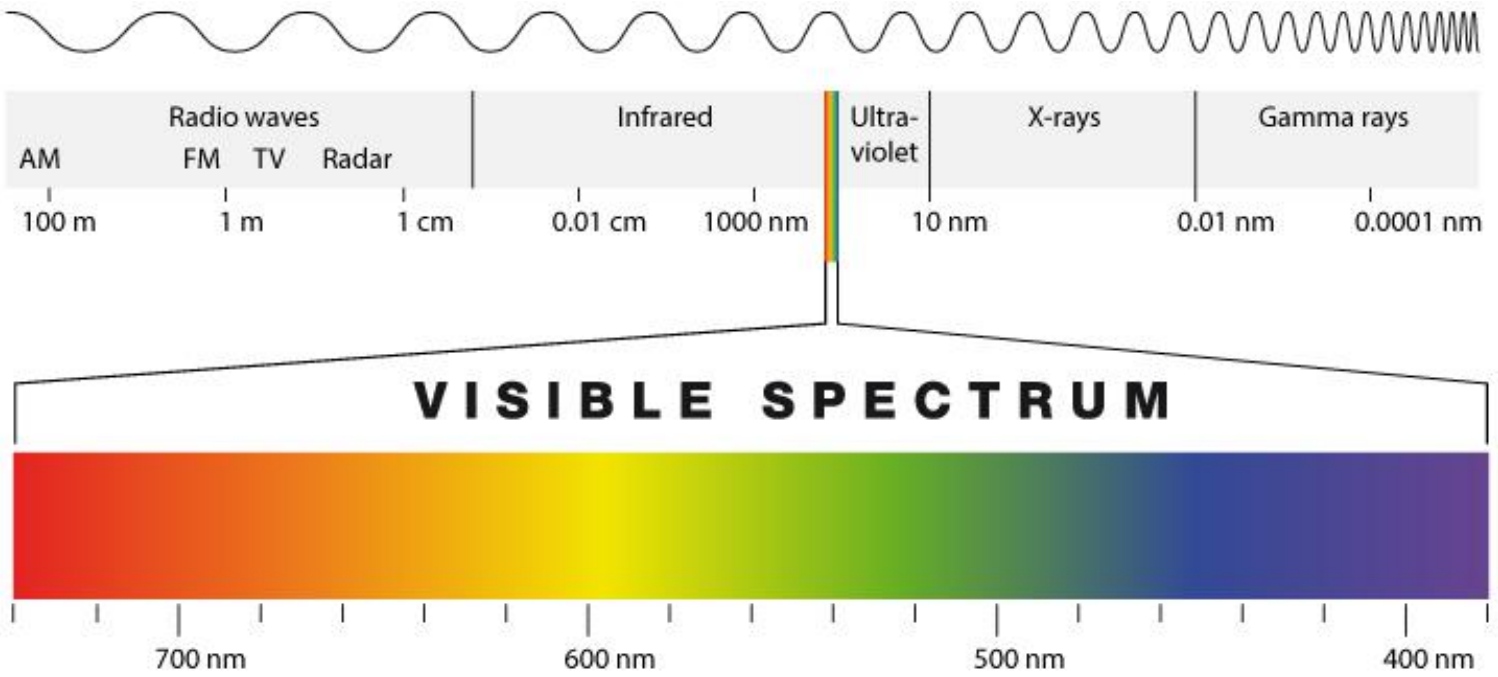
Image acquisition

- 빛
- 물체
- 물체가 반사하는 빛을 CCD/CMOS 등으로 전기신호로 만듦
- 전기신호의 값을 이용해 색/명암 등을 구별



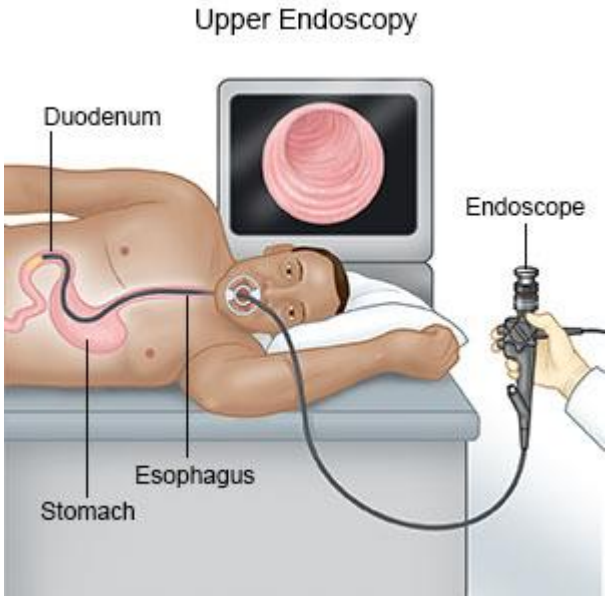
에너지 작음 → 인체 무해

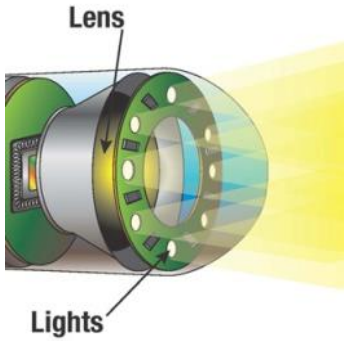
에너지 큼 → 인체 유해



5.Image acquisition

Endoscopy (내시경)





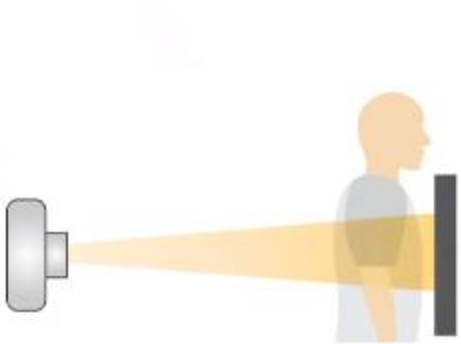
5.Image acquisition

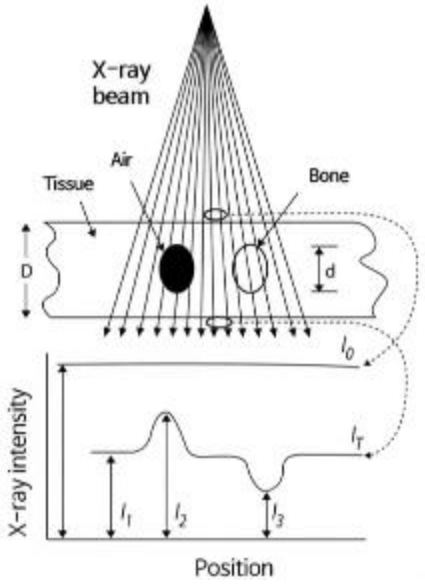
Microscopy (현미경)

6. X-ray / CT / PET

X-ray

- X-ray는 에너지가 큰 파장대이기 때문에, 몸을 통과함
- 몸을 통과하는 X-ray가 공기나 뼈를 통과하게 되면, 통과되는 X-ray의 양이 변화하여 X-ray intensity의 차이가 생김
- Detector에서는 X-ray를 전기신호로 바꿔주는 작업을 수행
- 전기신호의 차이로 최종 영상 (뼈 부분을 밝게 표현)

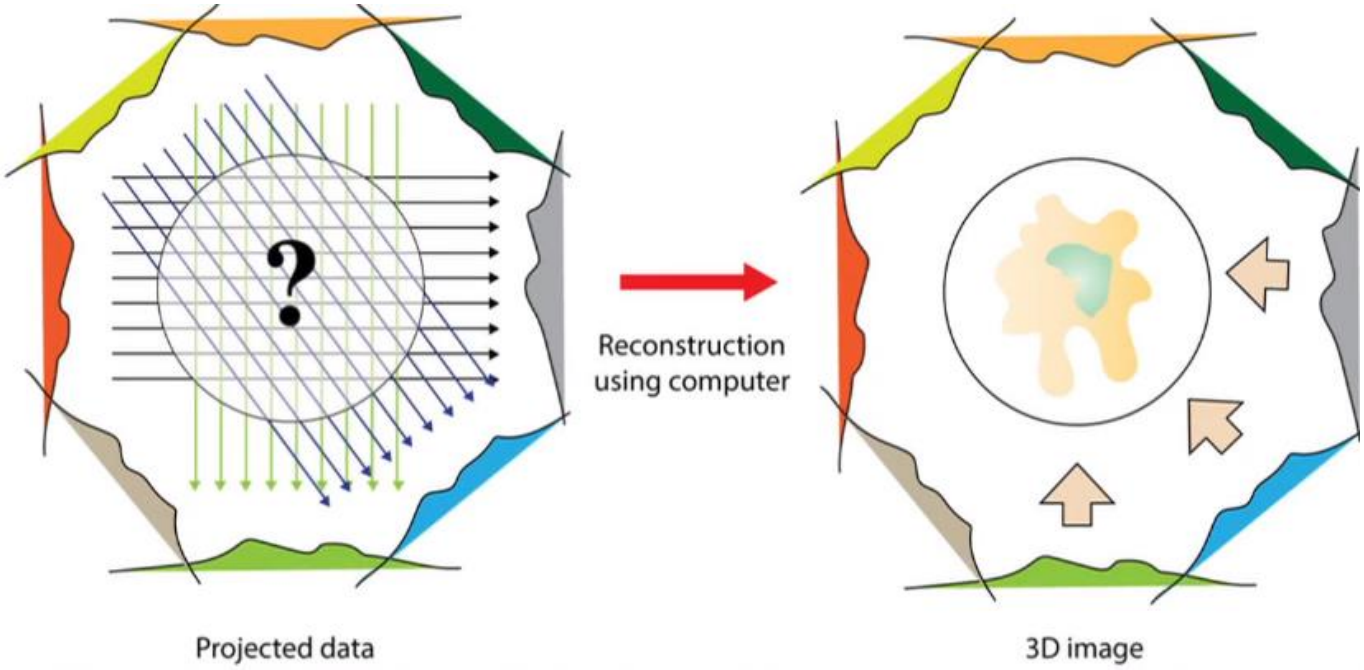




6. X-ray / CT / PET

CT (Computed Tomography)

- X-ray 원리를 이용하되, Computing 작업이 추가됨
- 여러 장의 2D 이미지 (X-ray)를 한 장의 3D 이미지로 변환
  - integral



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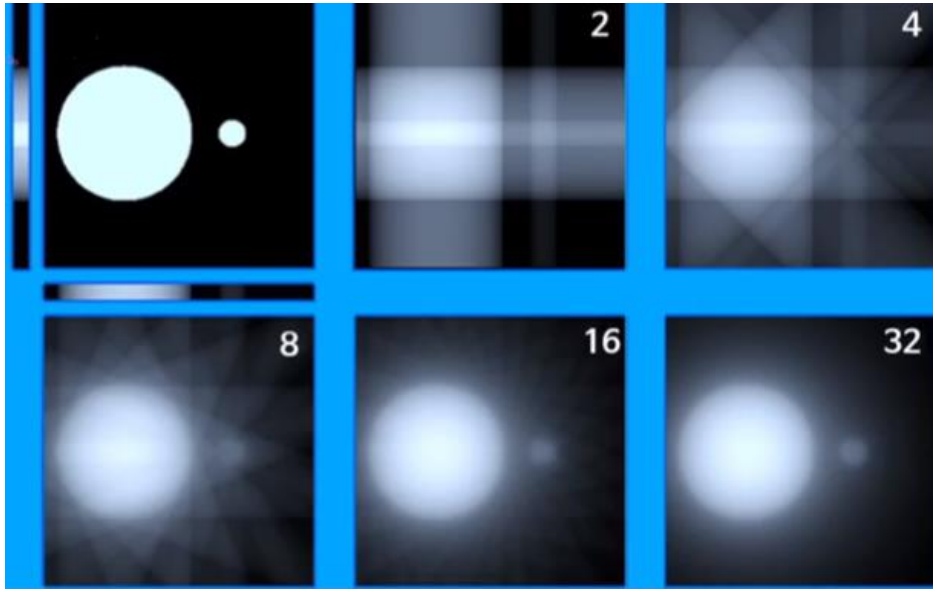
  - Integral

- 예 (1D → 2D 변환)
  - 여러 장을 찍으면 더 선명하지만, X-ray를 많이 쐬기 때문에 인체에 더 유해함
  - 따라서 적은 X-ray로 높은 퀄리티의 CT 영상을 Reconstruction 하는 것이 이슈임

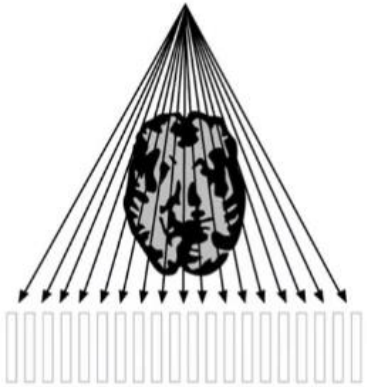


6. X-ray / CT / PET

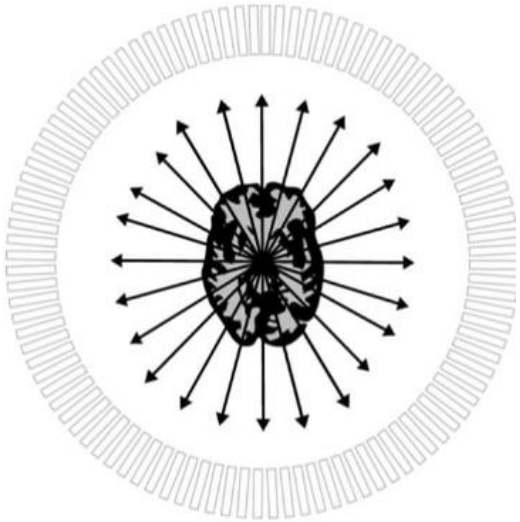
Positron Emission Tomography (PET)

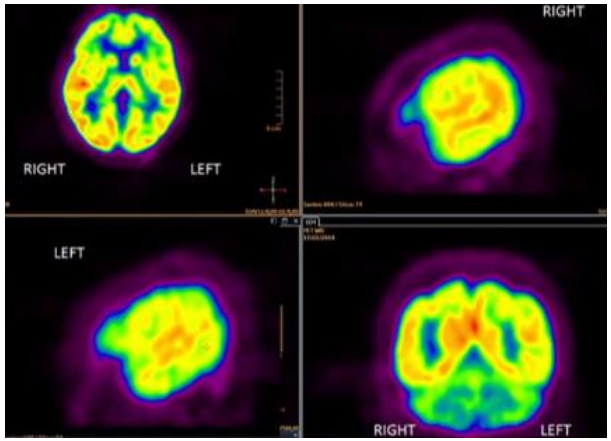
- X-ray/CT와 반대로 몸에 방사선 물질을 주입하고, 이를 밖에서 detect
  - 반감기가 짧은, 포도당과 유사한 방사선 물질 투여 → 포도당 대사 (metabolic function)가 활발한 곳 (주로 암세포 있는 곳에서 비정상적으로 많이 발생)에서 Positron 방출이 많이 발생 → 암 조기 진단에 활용
  - 방사선 원소들은 반감기에 따라 양전자를 방출 → 몸 안의 전자들과 양전자가 만나 소멸하면서 γ-ray 발생 → γ-ray는 양방향으로 방출됨 → 이를 외부에서 detect → 다양한 방향에서 detect 한 2D 이미지를 3D로 reconstruction
- Spatial resolution이 좋지 않음

X-ray



PET

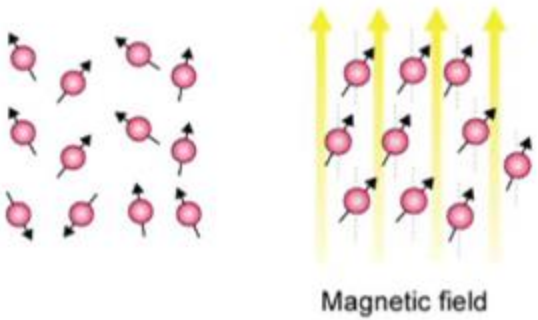




7. Magnetic Resonance Imaging (MRI)

MRI

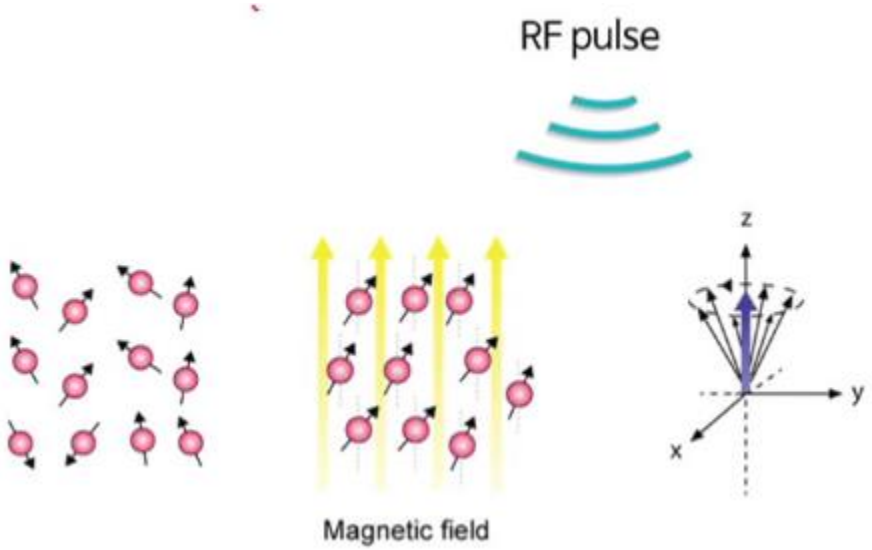
- Resonance (공명 현상) 이용
- 몸 안에 수소 원자가 많음. 수소 원자 핵들은 처음에는 random 방향을 갖고 있다가,
- 강한 magnetic field (노란 색) (1.5T, 3T, 7T …)에 의해 수소 원자핵들이 정렬하면서, 세차 운동을 하며 돌게 됨



7. Magnetic Resonance Imaging (MRI)

MRI

- 세차 운동 속도를 계산하여, 그 속도 만큼의 radio frequency (RF) pulse를 주게 되면 공명 현상이 일어남

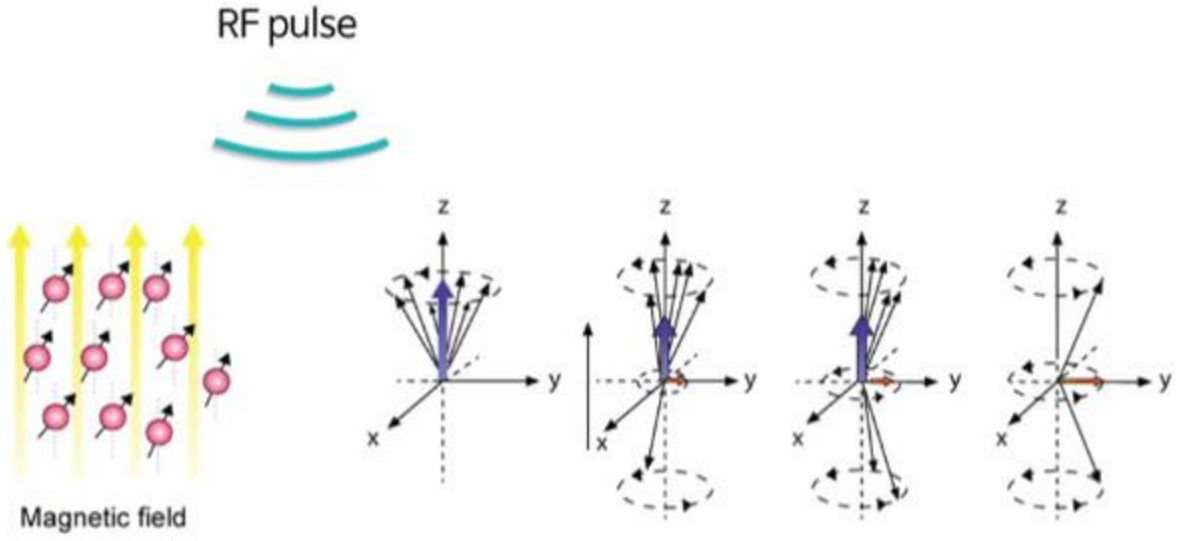


7. Magnetic Resonance Imaging (MRI)

MRI

- 자기장만을 가했을 때는, 수소원자핵들의 자기장이 다 같은 방향을 가리킴.

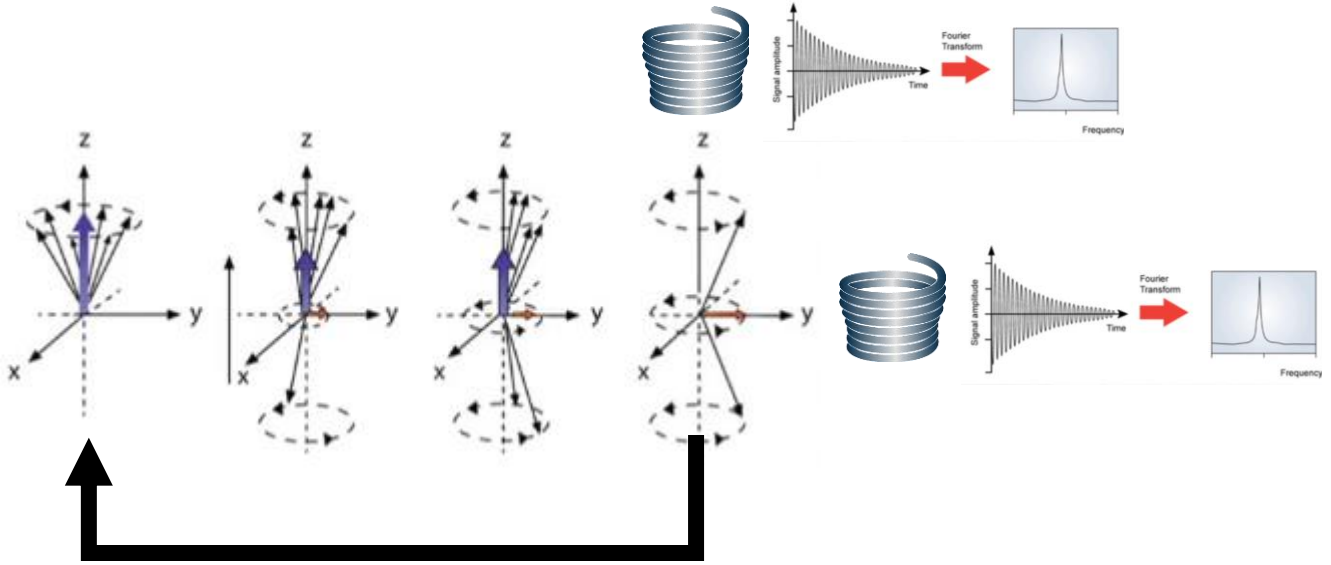
- 공명 현상이 일어나면 (RF pulse), 일부 수소원자핵에 에너지가 생겨 자기장 방향이 흔들림. 결과적으로 총 자기장 방향이 바뀌게 됨 (눕는 현상)



7. Magnetic Resonance Imaging (MRI)

MRI

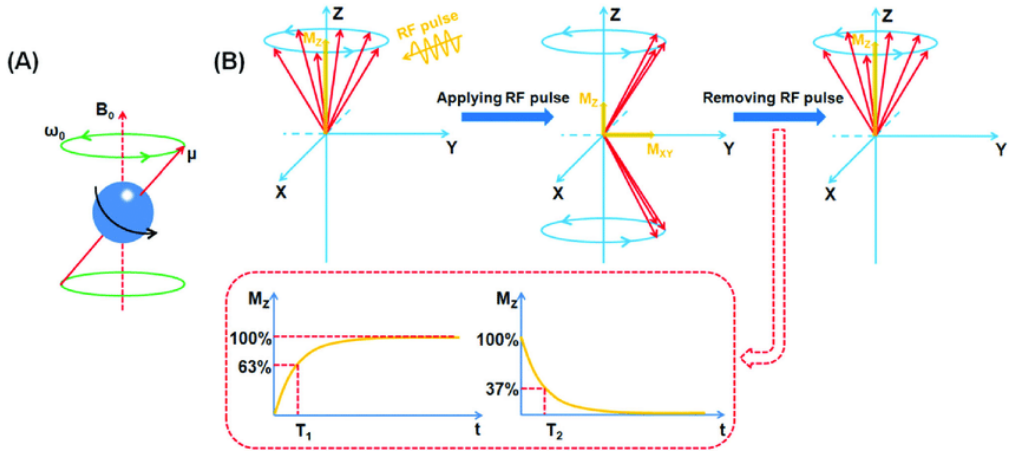
- 이 때 RF pulse 를 끊어버리면, RF pulse에 의해 생긴 에너지는 사라지기 때문에, 이에 따라 누워있던 자기장 방향이 돌아옴

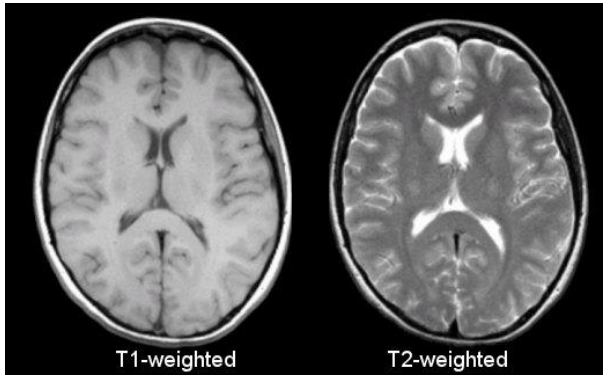


7. Magnetic Resonance Imaging (MRI)

MRI

- Y, Z 축에 있던 Receiver coil의 신호가 변화함 (Y 감소, Z 증가)
  - T1-weighted: Z축의 신호가 일정 수준 올라갔을 때 측정한 이미지
  - T2-weighted: Y축의 신호가 일정 수준 낮아졌을 때 측정한 이미지



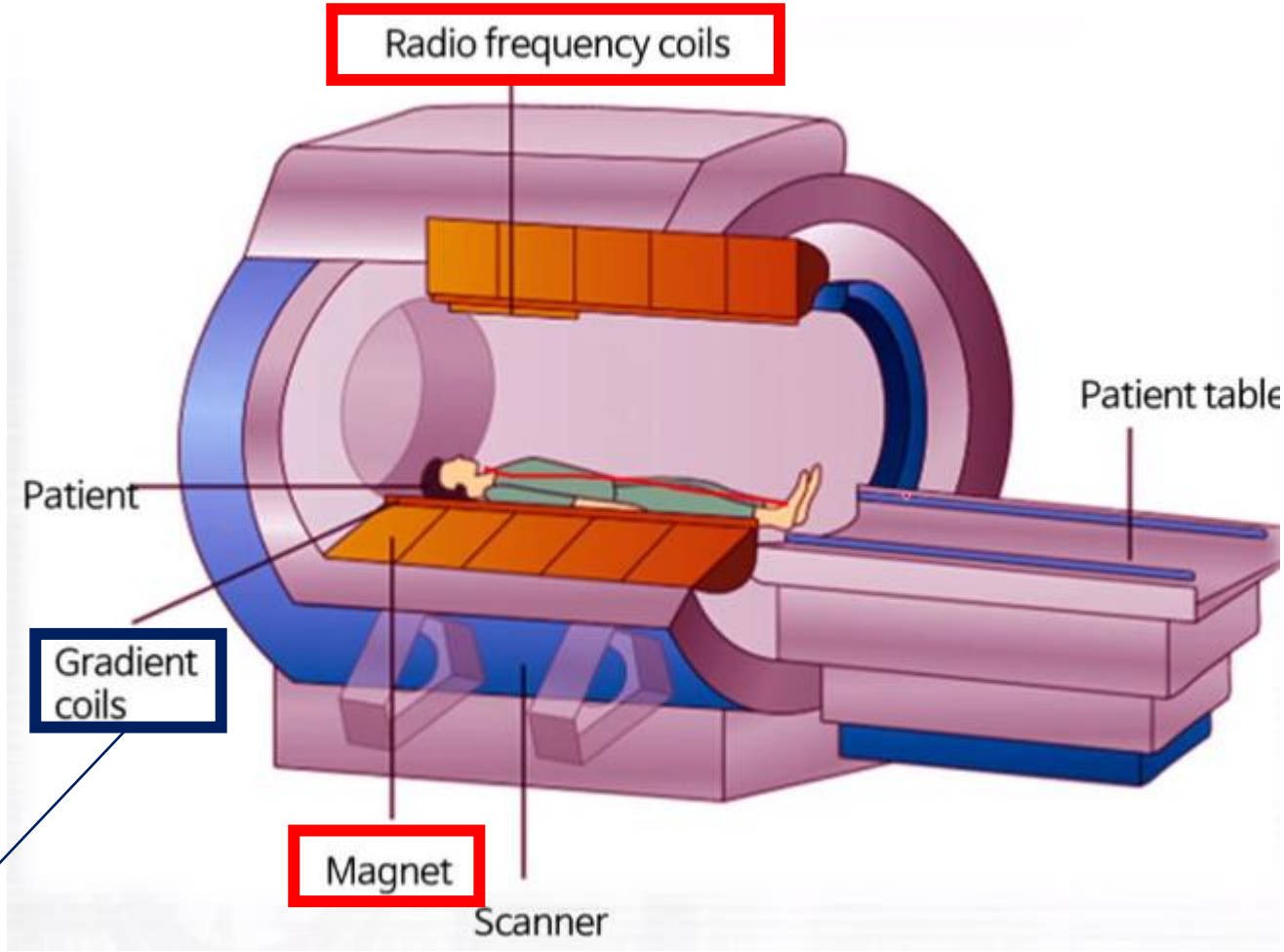


- Tissue마다 Coil의 신호가 변화하는 속도가 다르기 때문에 Tissue 간 Contrast가 가능함
  - Soft tissue 측정에 유리함

Cao, Y., Xu, L., Kuang, Y., Xiong, D., & Pei, R. (2017). Gadolinium-based nanoscale MRI contrast agents for tumor imaging. Journal of Materials Chemistry B, 5(19), 3431-3461.

7. Magnetic Resonance Imaging (MRI)

MRI



몸의 Point마다 다른 자기장을 주는 코일
(머리/가슴/배/다리 …)
부위별로 세차운동의 속도를 다르게 해서 특정 영역만 측정 가능하게 함.

7. Magnetic Resonance Imaging (MRI)

CT vs PET vs MRI

	Pros	Cons
CT	• Good for imaging of microfracture (미세골절), cerebral hemorrhage (뇌출혈), and calcification (석회화) • Short image acquisition time	• Radiation exposure • Contrast media (조영제 – 혈관 등 측정용) is dangerous for renal failure (신부전) patients (배출 안 되는 경우)
PET	• Studying metabolic functions in patients • Detecting disease before changes in the anatomy become apparent	• Radiation exposure • Requires cyclotrons which is an expensive machine to create the radioisotopes
MRI	• No radiation exposure • Good for imaging of soft tissues (muscle, ligament, brain nerves) • Detecting cancers in soft tissues	• Long acquisition time • Expensive