MUEI/MUNR
ETSEIB

Course on Medical Imaging
2022-203

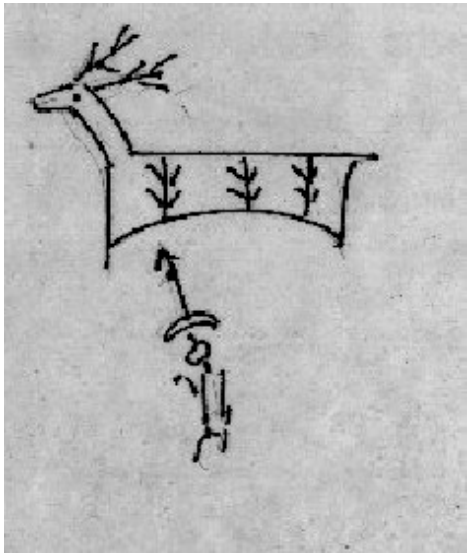
Session 1
Introduction to medical images

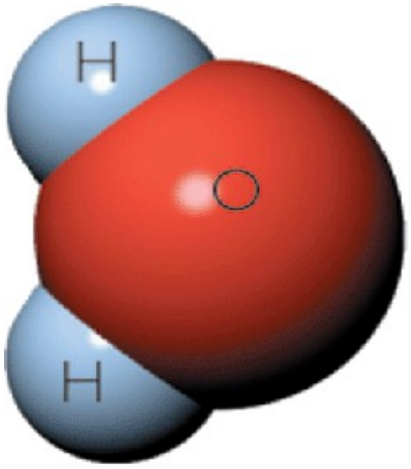
Dani Tost

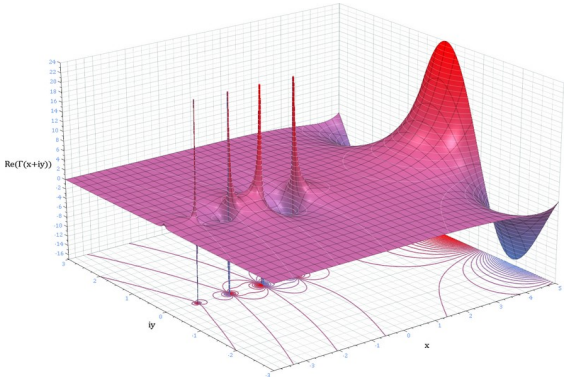
Introduction

An image is worth than 1000 words

More than 50% of human brain neurones are devoted to visual processing



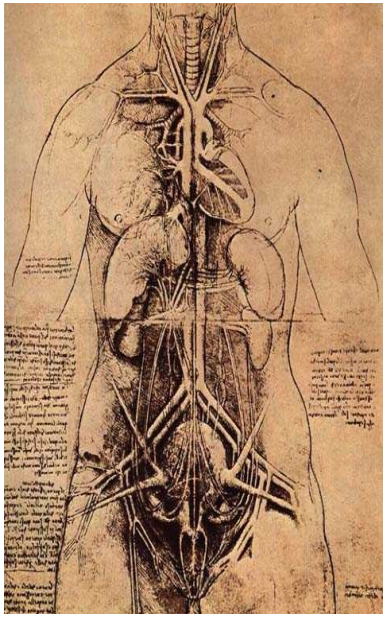


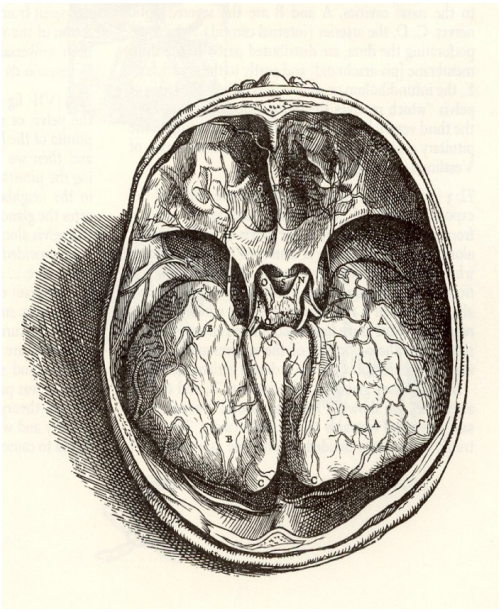


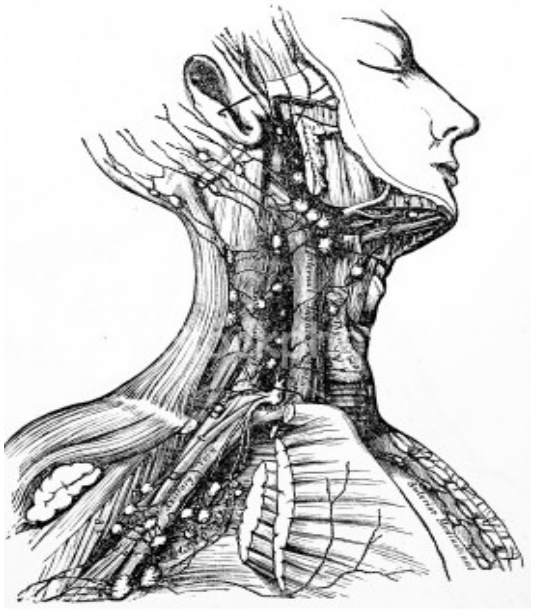
Medical illustrations

Need of illustrations in medicine

- *Mondino da Luzzi (Anathomia1316)*
- *Da Vinci (El hombre de Vitrubio, 1495)*
- *Vesalio 1530 (De humani corporis fabrica)*
- *Grey 1858, Anatomia de Grey*







Medical imaging
X-Rays

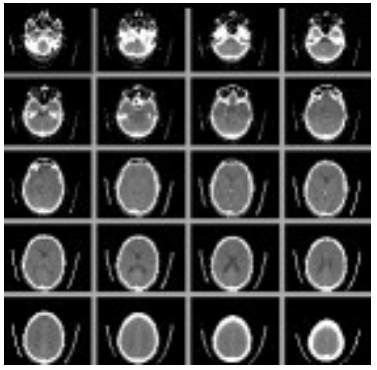
The discovery of X-Rays by W.C.Roentgen in 1895 opens the possibility of viewing the internal body in-vivo.

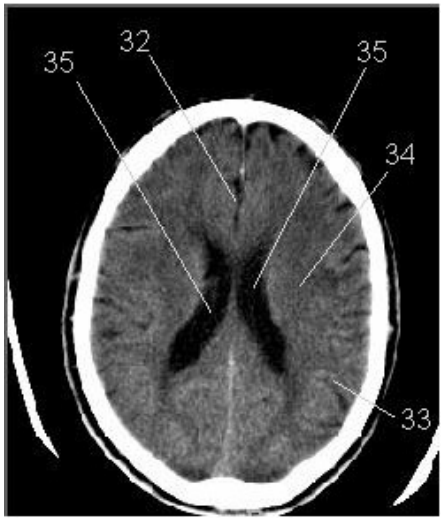
X-rays are ionizing electromagnetic waves of photons that are attenuated by matter. The attenuated rays can be captured by a photographic plate (nowadays digital detectors) to create images.

Medical imaging
Computed tomography

The discovery of Computerized Tomography by Cormack (1957) and Hounsfield (1972) opens the possibility of viewing the internal body in vivo and in 3D

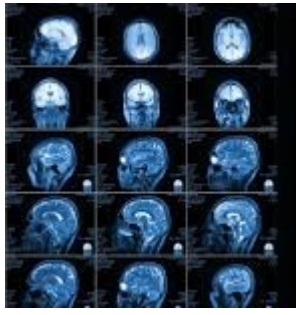
Siretom CAT, EMI, 1974

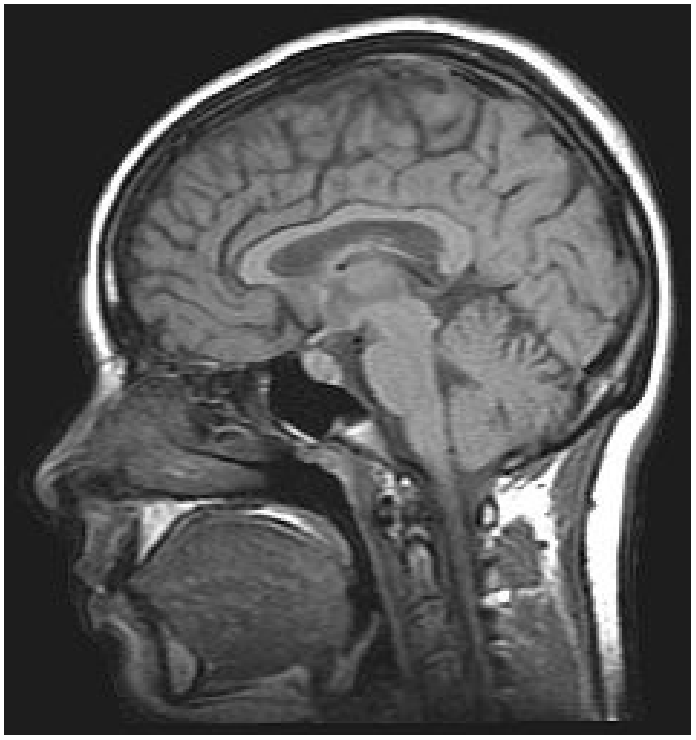




Medical imaging
Magnetic Resonance

In the early 80's **Magnetic Resonance Imaging** was introduced in the hospitals. It is based on magnetic fields and radio waves, thus, **it does not use ionizing radiation.** It provides precise images of soft tissue structures





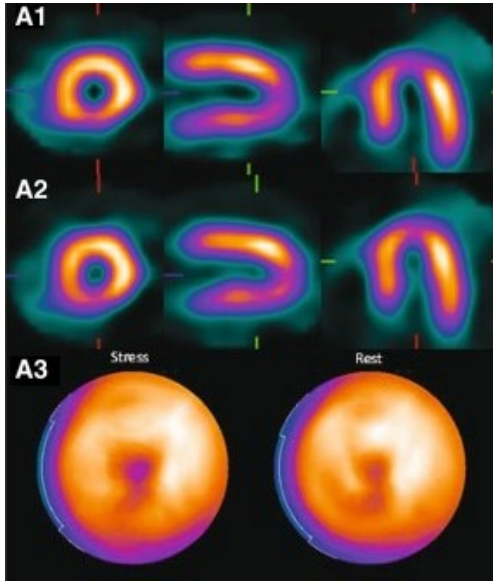
Nuclear imaging

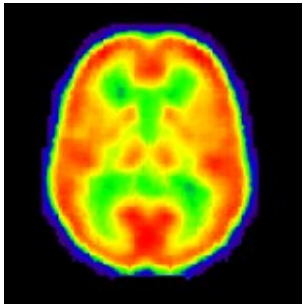
Nuclear imaging (SPECT, PET) was developed in the late eighties (after the concept was proposed 1962 by David Kuhl) in an attempt to visualize physiology instead (in addition to) anatomy.

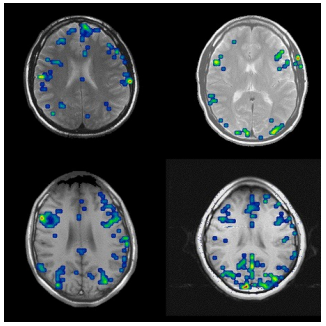
In nuclear medicine, nanograms of radioactive tracers are injected into patient

Tracer accumulated in the tissue emits gamma rays that are captured to reconstruct an image

Nuclear images are used in functional studies of the brain, tumor detection and evolution follow up, densitometry and a variety of applications.







Ultrasounds

The use of ultrasound in medical imaging began shortly before the 2nd World War, following Karl and Frederick Dussik «hyperphonography» apparatus (1947).

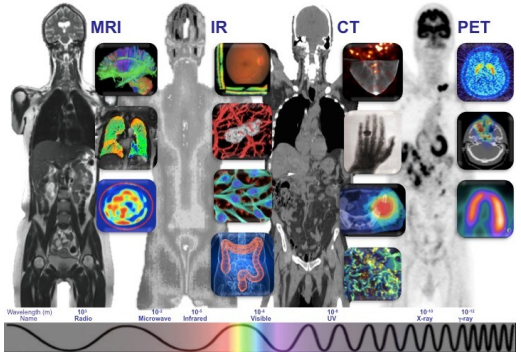
Today at least 30% of all medical imaging worldwide.

US are based frequency of the sound waves used in medical ultrasound is in the range of millions of cycles per second (megahertz, MHz). In c[illegible]th[illegible] range of audible frequencies for hu[illegible] thousand cycles per second (20 kH[illegible]

Medical imaging

Since then, many modalities and submodalities have been developed that provide each time a better insight into the human body.

- X-rays
- CT: Computed Tomography (CAT: Computed Axial Tomography)
- CTA: Computed Tomography Angiography
- Magnetic Resonance Imaging (MRI)
- MRA: Magnetic Resonance Angiography
- FMR: Functional magnetic Resonance
- DTI: Diffusion Tensor Tractography
- SPECT: Single Positron Emission Computed Tomography
- PET: Positron Emission Tomography
- US: Ultrasound (2D, 3D, 4D)
- Thermal (infrared) imaging
- And others ....



Medical imaging

Name	Acron.	Indications	Dim	Harmfulness	Spatial resolution	Acquisition time	Cost
X rays	XR	fractures joints pain respiratory issues	2D	Based on ionizing radiation (2-3 days to 100 days of natural radiation)	0.5 to 0.2 mm	1-2’	$250 -$500
Computed Tomography	CT CTA	Bones and lungs tumors and fractures guided procedures CTA for blood vessels	3D	Based on ionizing radiation Contrast agent can cause allergy	0.5-0.625 mm in normal CT 400 nm in nano-CT	10’	$300 – $2.500
Magnetic Resonance	MR MRA fMR	Central nervous system, joints, organs, musculature, and other soft tissue structures	3D	Based on Magnetic waves. Harmless. Contrast agents can cause allergy	1-2 mm	45’	$1200 - $4000
Ultrasound	US	Abdomen structures Fetus Heart	3D/4D	Based on sound waves Harmless (limited time of exposition)	0.5mm	30’-60’	$100- $1000 ~ $450
Emission Tomography	PET	Measures activity. Cancer, Heart diseases, CNS diseases (Alzheimer, Parkinson)	3D	Based on radiotracers Harmful	1- 2.5 mm	90’ to 240’	$2000- $9000 ~$5500

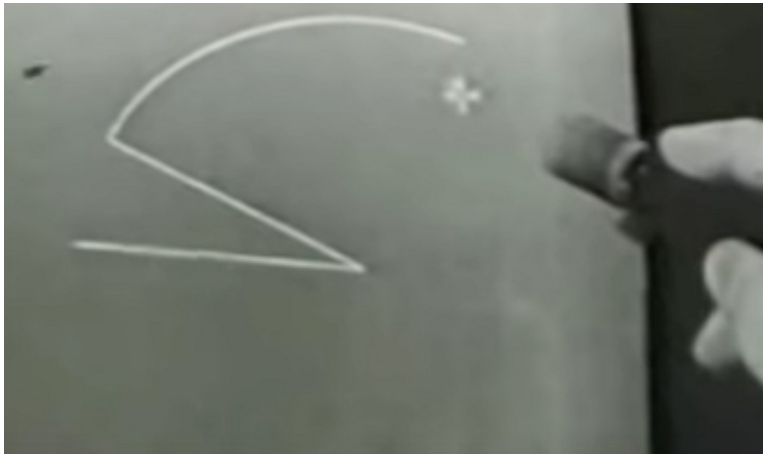
Computer Graphics

The pictorial **synthesis** of **real or imaginary** objects/scenes from their computer-generated models in the form of digital images (and videos)

"La trahison des images",
R. Magritte 1948

Computer graphics
A spectacularly fast evolution

Ivan Sutherland's sketchpad (MIT, 1963) is considered the beginning of Computer Graphics



https://youtu.be/6orsmFndx_o

Computer Graphics
A spectacularly fast evolution

Hardware & software

1976 – 1995: Early days

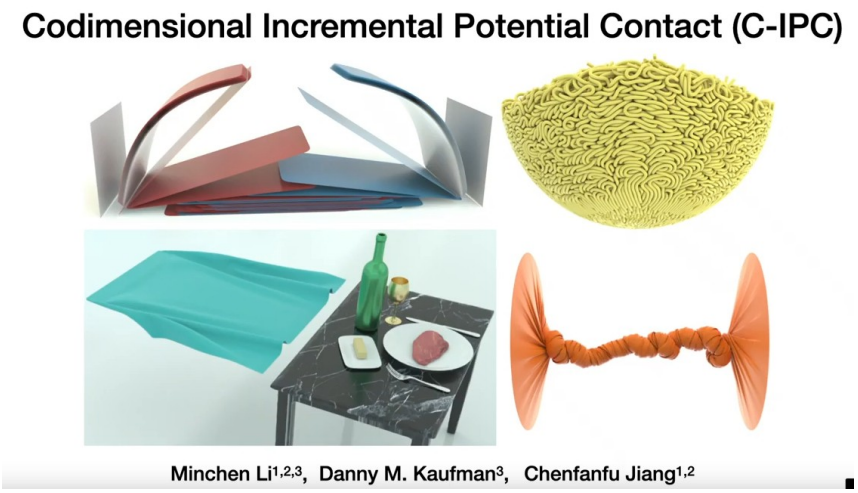
1995 – 1999: First consumer PC graphics cards

2000 – 2006: Programmable GPU (Graphics Processing Unit)
Nvidia, ATI

2006 – 20XX: Modern fully massively parallel processors
General purpose computation (GPGPU)
Deep learning
New non-graphic applications

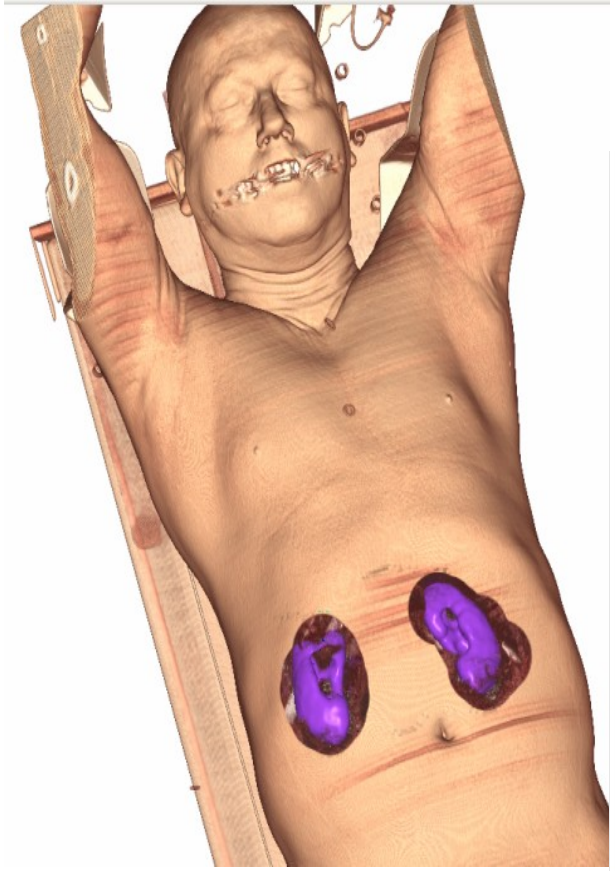
See nVidia home page https://www.nvidia.com/en-us/about-nvidia/
List in https://www.computerhope.com/history/videocard.htm

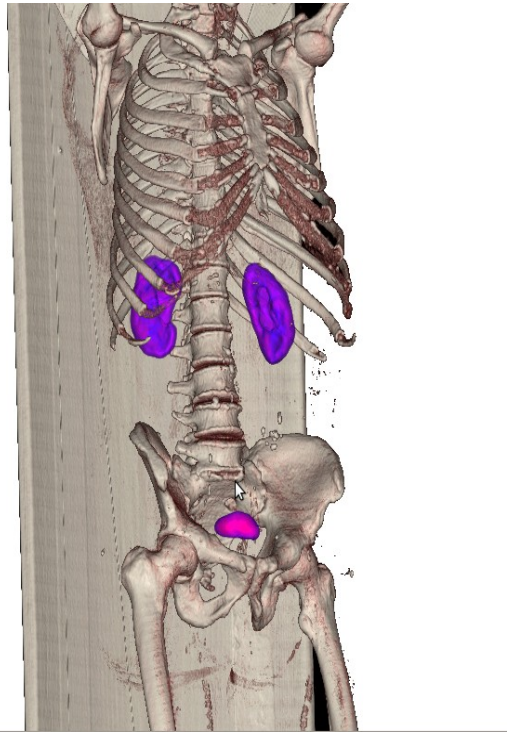
Computer Graphics
A spectacularly fast evolution

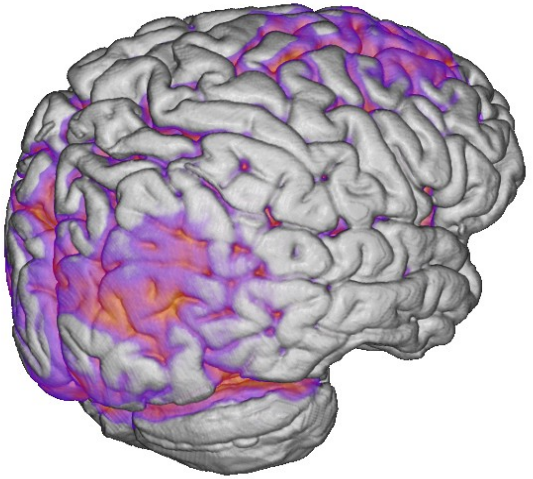


Extracted from SIGGRAPH 2021 and SIGGRAPH 2022

Computer graphics meets medical imaging







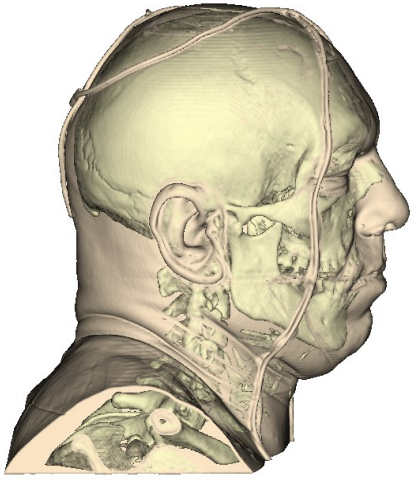


Image processing

Analysis or reconstruction of objects/scenes from image data.

Computer Graphics

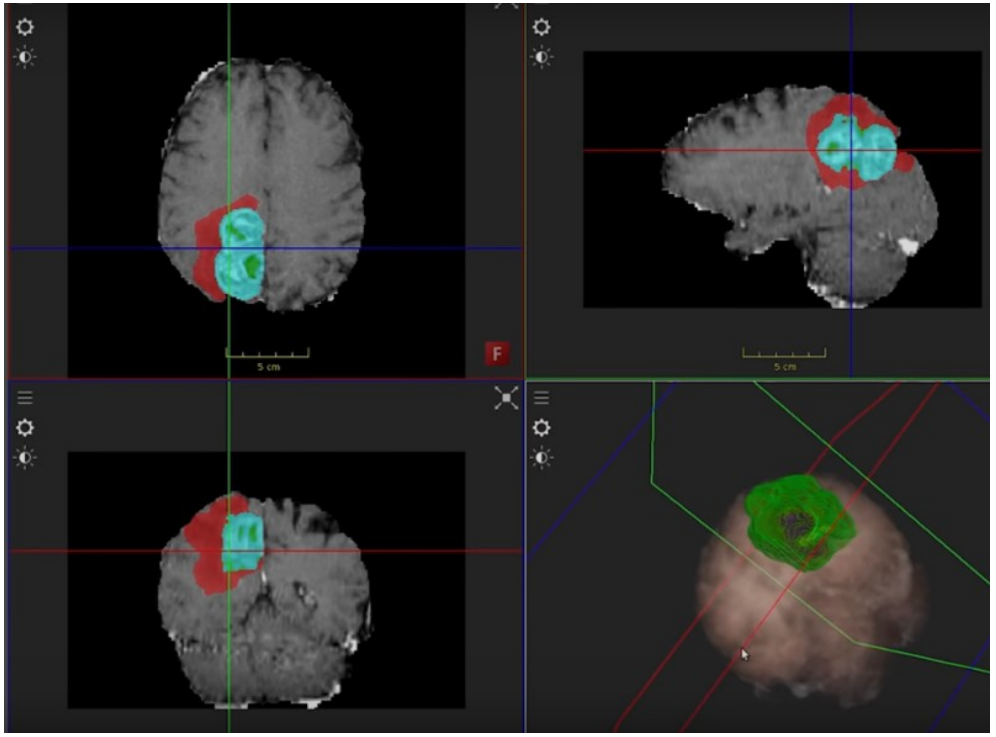
Image processing

Computer Generated Imagery

Image extracted from: «Scalable Locally Injective Maps», M. Rabinovich, R. Poranne, D. Panozzo, O. Sorkine-Hornung, ACM Transactions on Graphics, 2017

Image processing and AI meets medical imaging

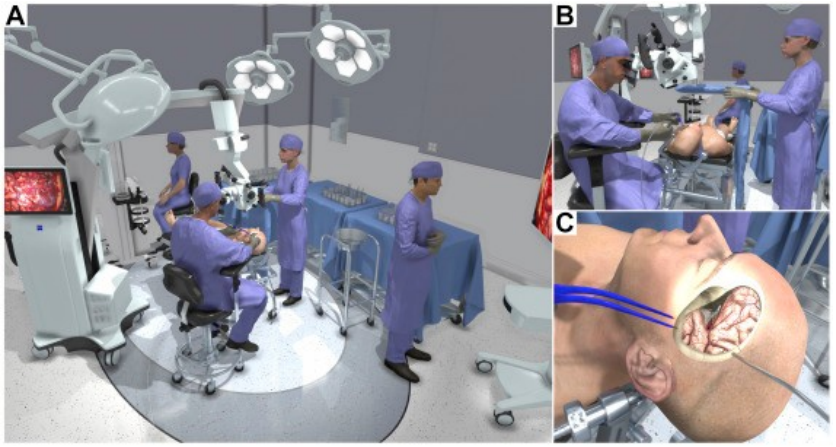
Deep learning techniques allow to analyze images in ways that were not imaginable just a decade before.



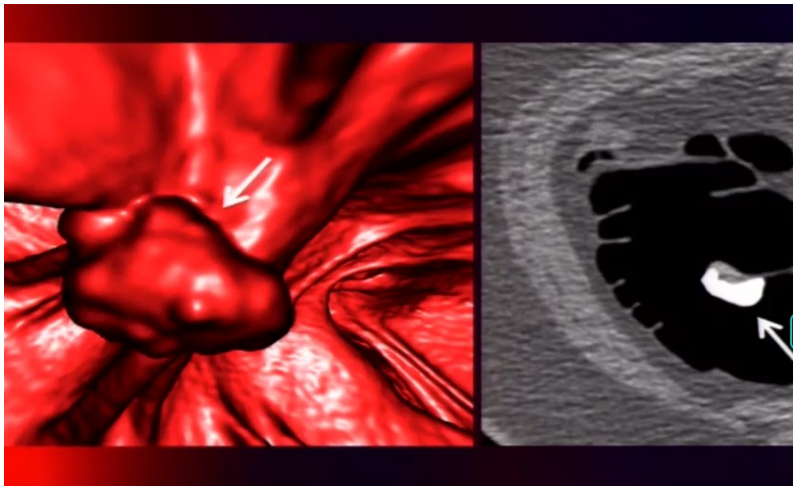
An overview of deep learning in medical imaging focusing on MRI
Alexander Selvikvåg Lundervoldab Arvid Lundervold
https://www.sciencedirect.com/science/article/pii/S0939388918301181#fig0015

https://www.nvidia.com/en-us/deep-learning-ai/

Applications



Neurosurgery from Immersive Three-Dimensional Modeling and Virtual Reality for Enhanced Visualization of Operative Neurosurgical Anatomy
Tomlington et al. 2019



Virtual colonoscopy
https://www.youtube.com/watch?v=IT0IazZAFoo

Training with virtual patients-
https://www.virtro.ca/

Augmented Reality for Image Guided Therapy
https://www.youtube.com/watch?v=Ngcb9UlqcJA

Course syllabus

- 2D graphics
- 3D graphics
- Images
- Volumes
- Graphical interfaces