

Medical Computing:

The role of technology in the advancement of medicine

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Introduction

- Queen's University, Kingston, ON, Canada



Introduction



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Tamas Ungi, PhD

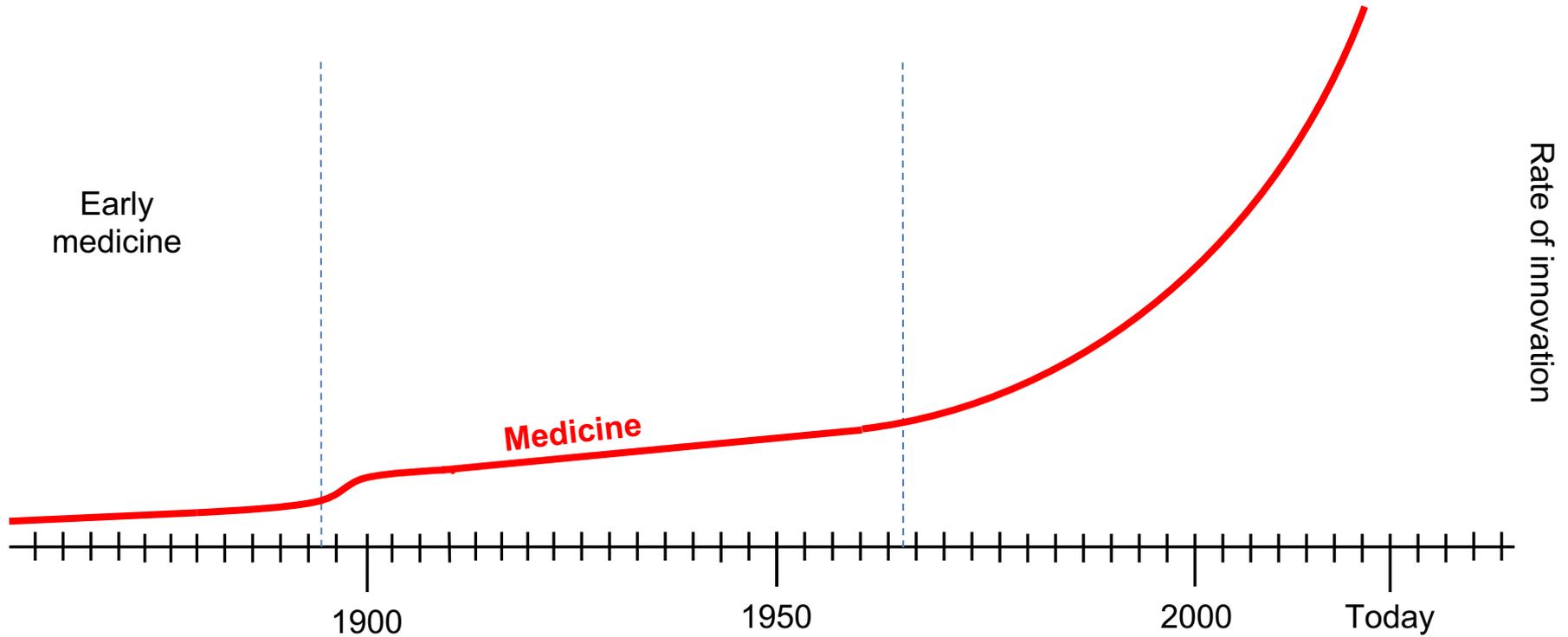


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MSc



Rebecca Hisey,
PhD Candidate

Timeline



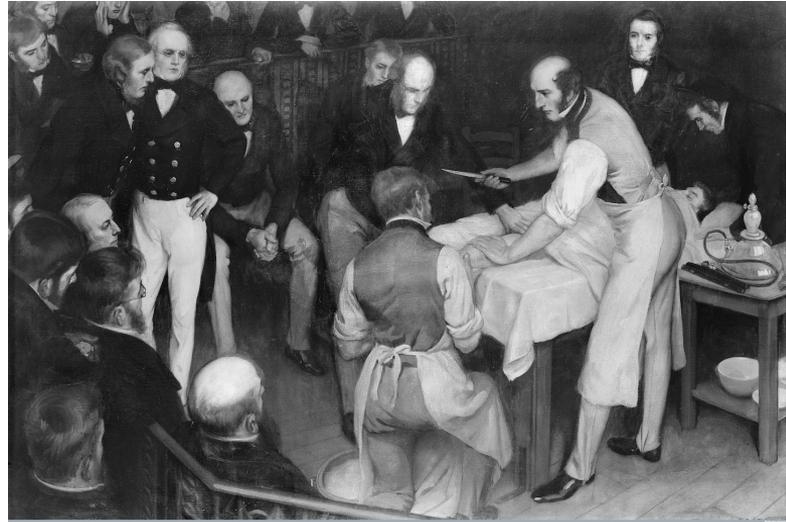
Early Medicine

- No imaging modalities exist
- Physicians reliant on what they can see with their own eyes



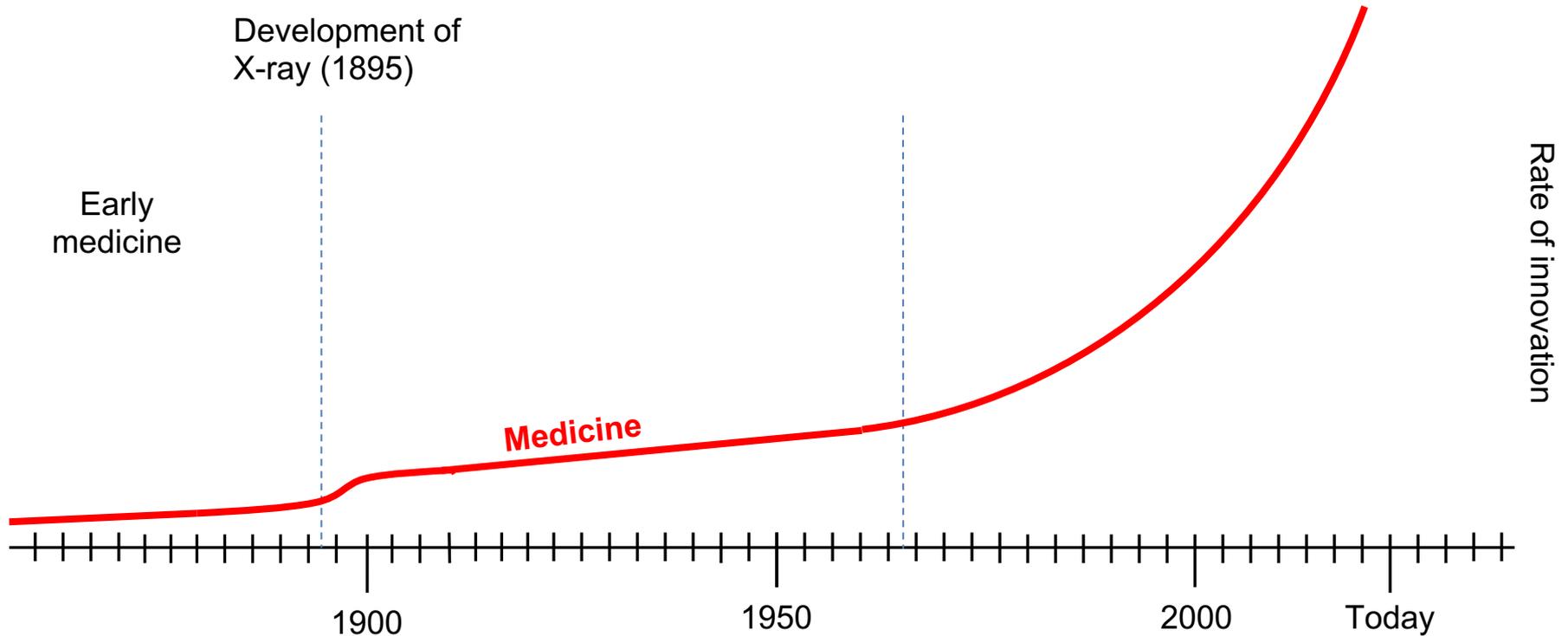
Early Medicine

- Seeing inside the body required cutting into the body
 - Limited anesthesia
 - Little understanding of infection control



<https://www.washingtonpost.com>

Timeline



Development of X-rays

- The discovery of X-rays spurred a large number of advances in both imaging and treatment



Development of X-ray

- Developed by German scientist Wilhelm Conrad Röntgen
 - Discovered that rays emitted from cathode tubes could penetrate through materials
 - Rays passed easily through soft tissue, but could not pass through metal or bone

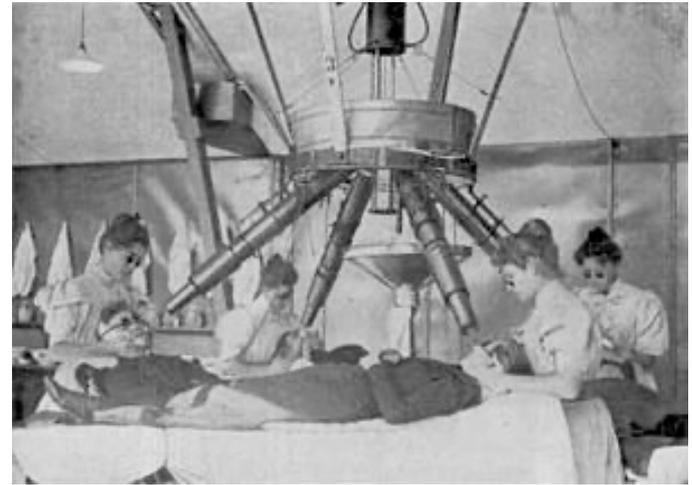


Birth of radiology

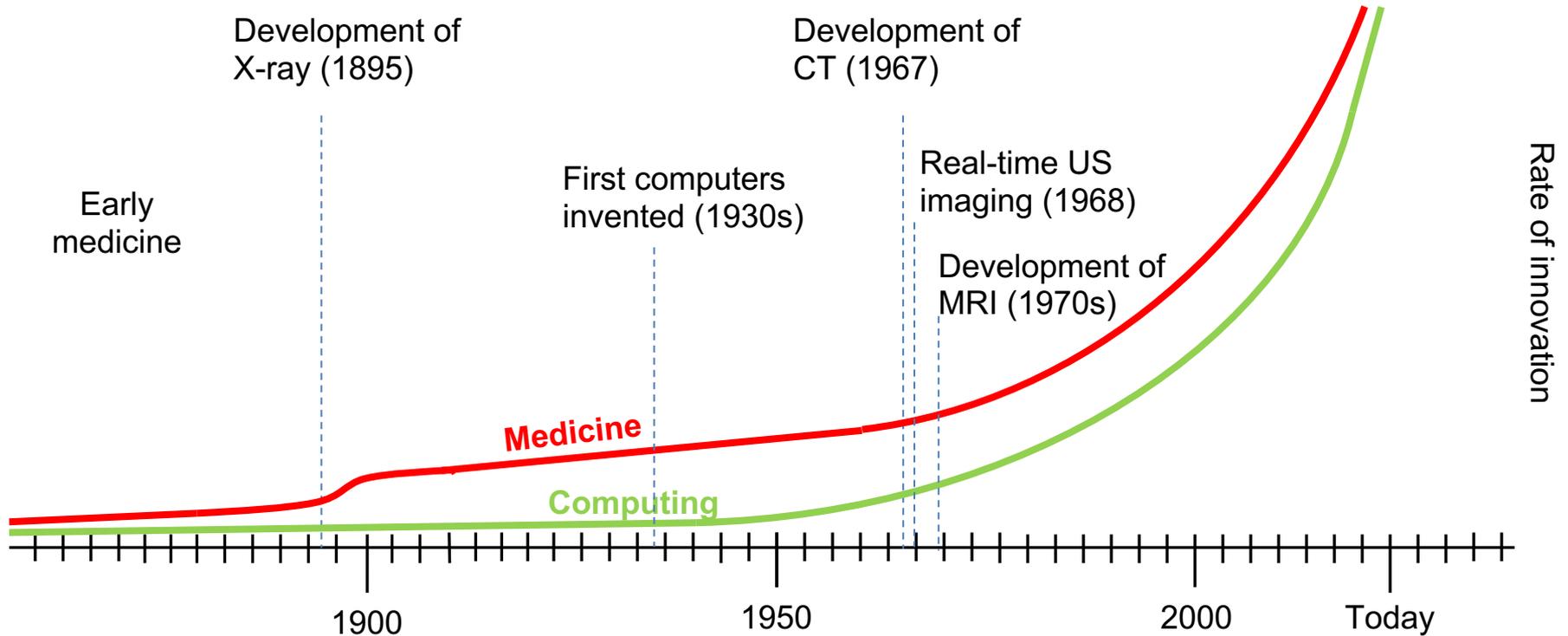
- After its discovery, its potential for clinical use was recognized immediately
 - First papers using X-rays for imaging bone fractures emerged less than 1 year later

Other uses of X-rays

- In 1896 physicians began to notice that x-rays had a palliative effect on some cancers
 - The beginning of radiation therapy

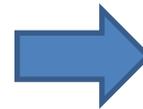
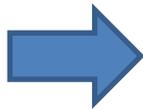


Timeline



Rise of computing

- The first computer was developed in 1930
- Rapid advancement from 1930-1970 when the first personal computers were developed



Rise of computing

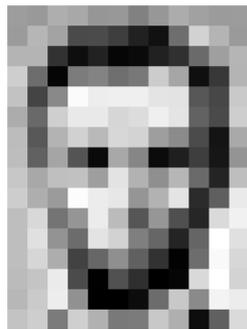
- With the addition of graphical displays, technology for digital image representation quickly arrived



The first digital image

Digital imaging

- Using light to represent analog signals meant medical images could be represented digitally
- Images were divided into small equal regions
→ Pixels → Assigned a numeric intensity value



187	183	174	168	160	162	129	161	172	161	165	166
155	182	163	74	75	62	33	17	110	210	180	154
180	180	50	14	34	6	10	33	48	106	159	181
206	109	6	124	131	111	120	204	166	16	56	180
194	68	137	251	237	239	239	228	227	87	71	201
172	105	207	233	233	214	220	239	228	98	74	206
188	88	179	209	185	215	211	168	139	75	20	169
189	97	165	84	10	168	134	11	31	62	22	148
199	168	191	183	158	227	178	143	182	100	36	190
205	174	156	282	236	231	149	178	228	43	96	234
190	216	116	149	236	187	86	150	79	38	218	241
190	224	147	108	227	210	127	102	36	101	258	224
190	214	173	66	103	143	96	90	2	109	249	215
187	196	236	75	1	81	47	0	6	217	256	211
183	202	237	145	0	0	12	108	209	138	243	236
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<https://ai.stanford.edu/~syyeung/cvweb/tutorial1.html>

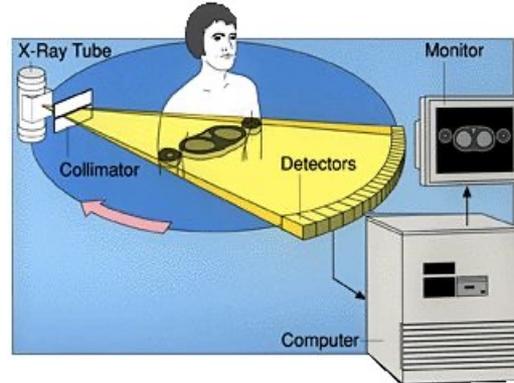
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Computed Tomography

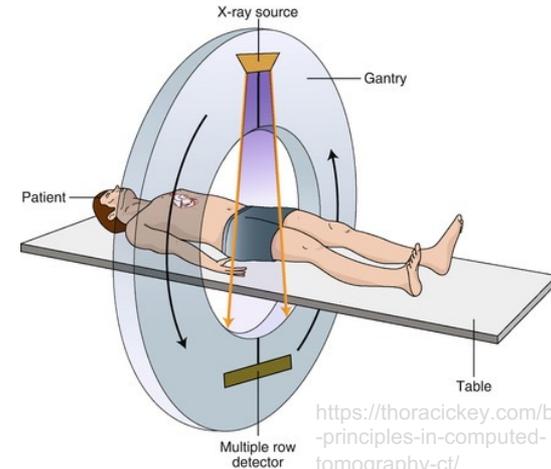
- More powerful computers + digital image representation → more advanced imaging
- Computed tomography (CT) was one of the first in this new era
 - Developed in 1967
 - Just prior to the release of the first PCs

Computed Tomography

- Uses X-ray source and detector on a rotating gantry
 - Scans are taken in thin slices then reconstructed into 3D volumes



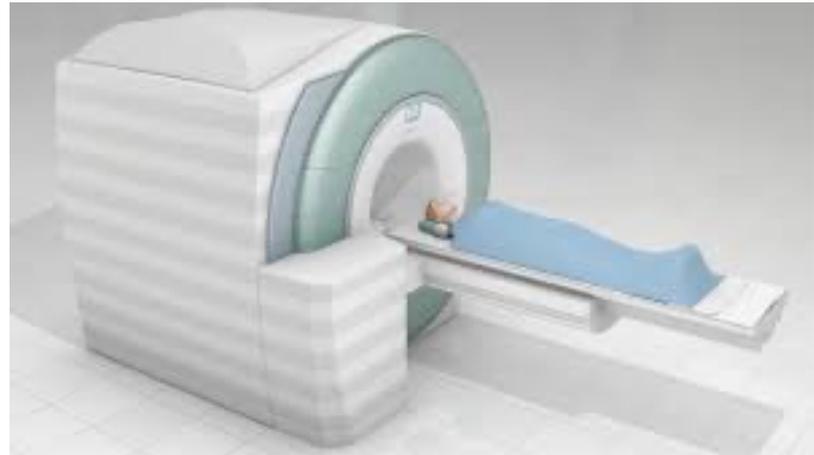
<https://www.imaginis.com/ct-scan/how-does-ct-work?r>



<https://thoracickey.com/basic-principles-in-computed-tomography-ct/>

Magnetic Resonance Imaging

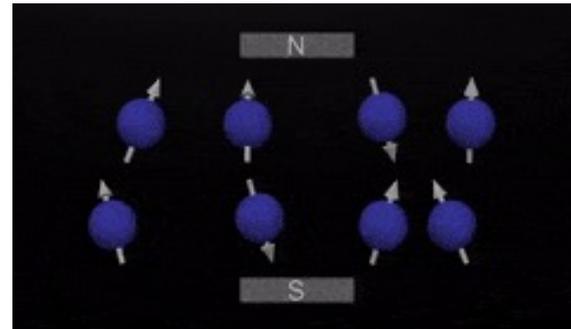
- Developed around same period as CT
- Similar reconstruction principle, but different physics



https://www.hopkinsmedicine.org/health/treatment-tests-and-therapies/magnetic-resonance-imaging_mri_

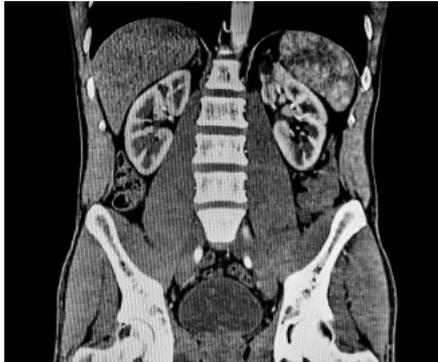
Magnetic Resonance Imaging

- Magnetic field is applied to the patient, as atoms return to a resting state they emit signals
 - Different tissue types show different rates of relaxation

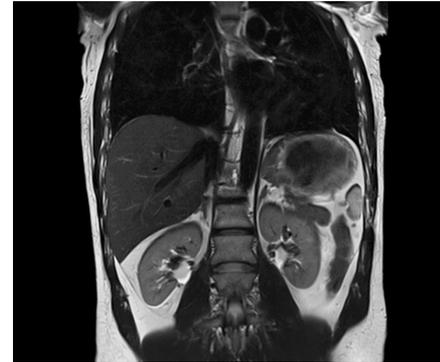


MRI vs CT

- Reconstructed through similar methods
- Different physics of image generation leads to vastly different image properties



CT



MRI

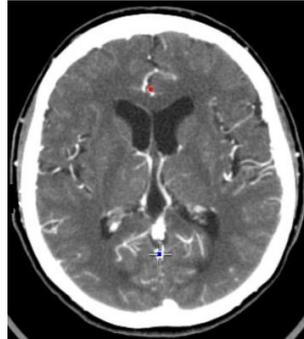
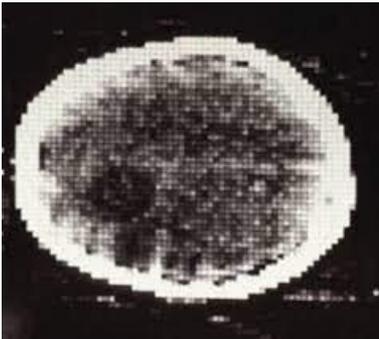
Real-time imaging

- Another major advancement in this period was the invention of real-time imaging
 - Fluoroscopy
 - Ultrasound
- Time-series of images

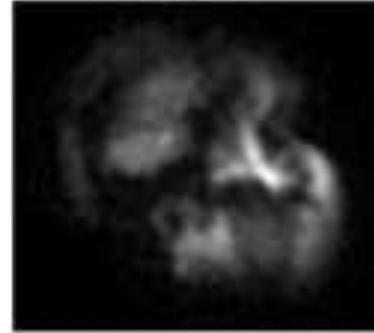


Continued advancement

- As technology has advanced, so has the quality of images
 - Images show more and more detail



CT



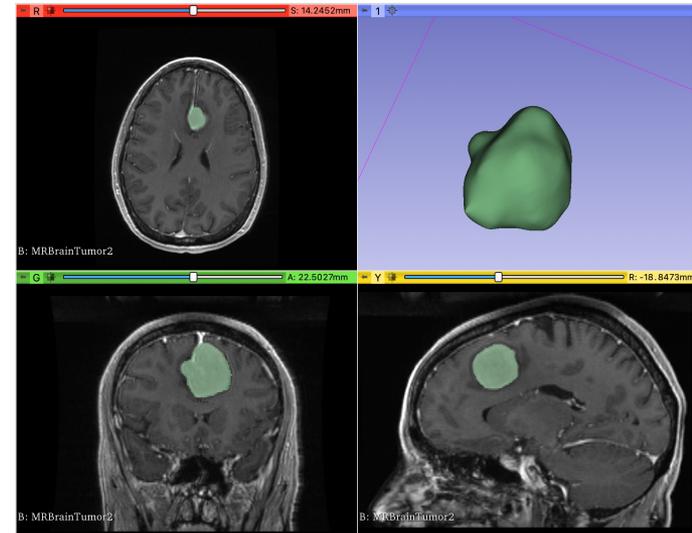
MRI

Too much information?

- As image quality increases, so does the amount of information physicians are given
 - Now there is so much detail that it is difficult to remove details that are irrelevant

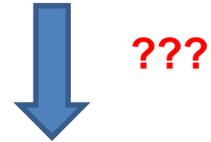
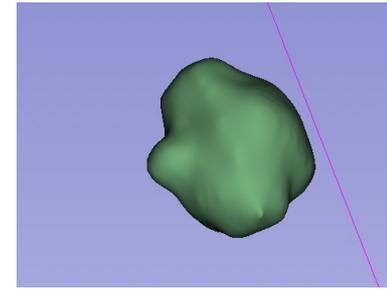
Reduction of information

- Provide as much information as needed while removing irrelevant details
 - Rendering
 - Segmentation



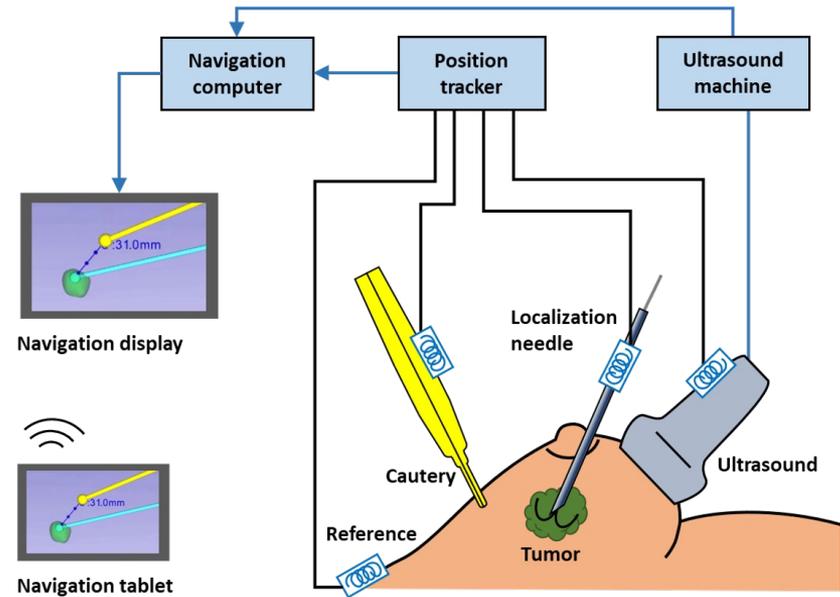
Providing context

- Relying on imaging created a disconnect between the screen and the patient
 - Reduction of information makes it more challenging to register structures back to the patient



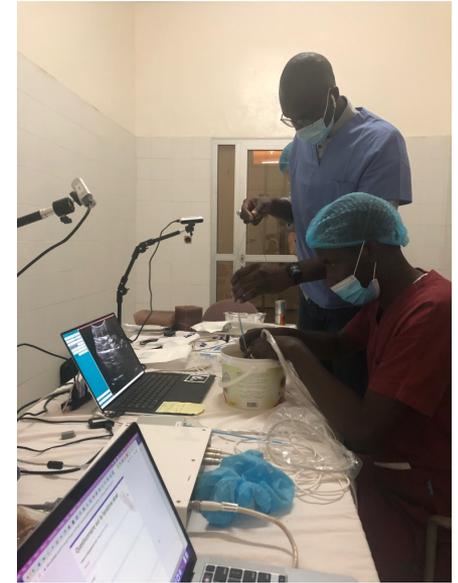
Surgical navigation

- Tracking allows us to localize segmented structures with respect to surgical tools
 - Surgeons can see where they are working compared to the anatomy

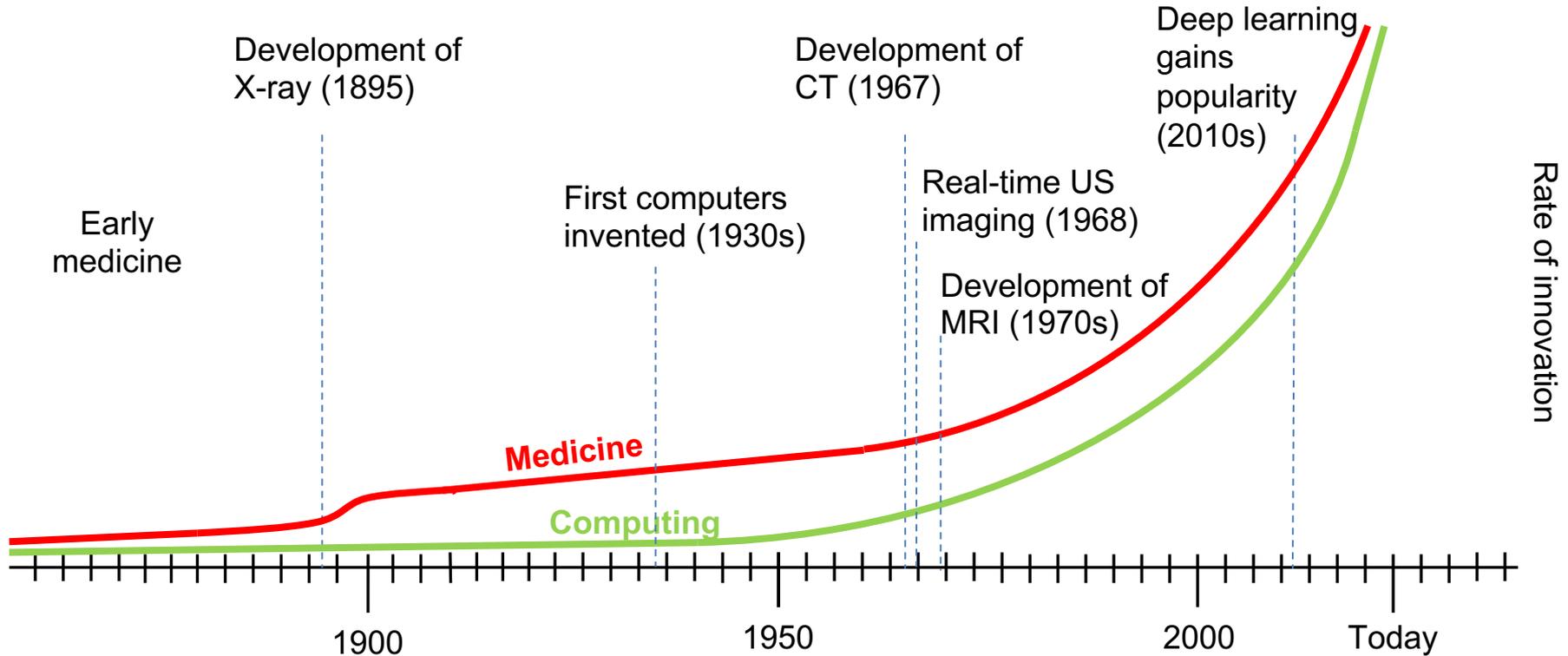


Our work in Dakar

- Development of a surgical navigation system for percutaneous nephrostomy

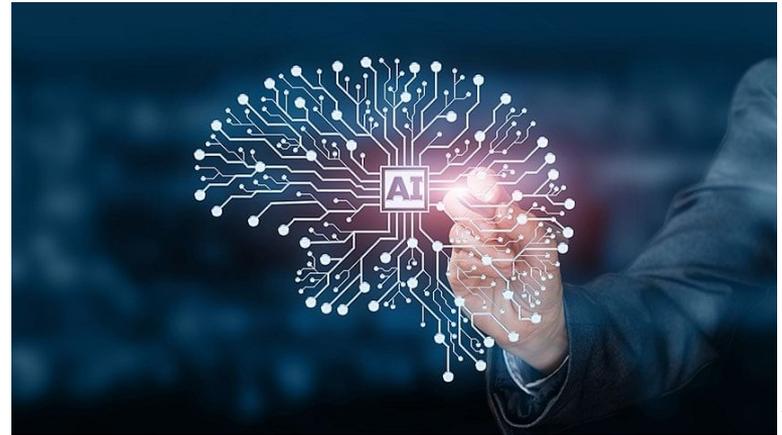


Timeline



What's Next?

- Age of Artificial intelligence
- Deep learning has created systems that can analyze images to detect subtle differences not visible to humans
 - Diagnosis
 - Segmentation
 - Tracking
 - And more!!



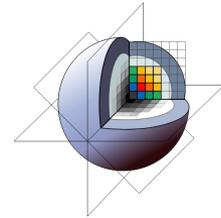
Acknowledgements

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