Aula 01 – Introdução ao processamento de imagens

Prof. João Fernando Mari
joaofmari.github.io
joaof.mari@ufv.br

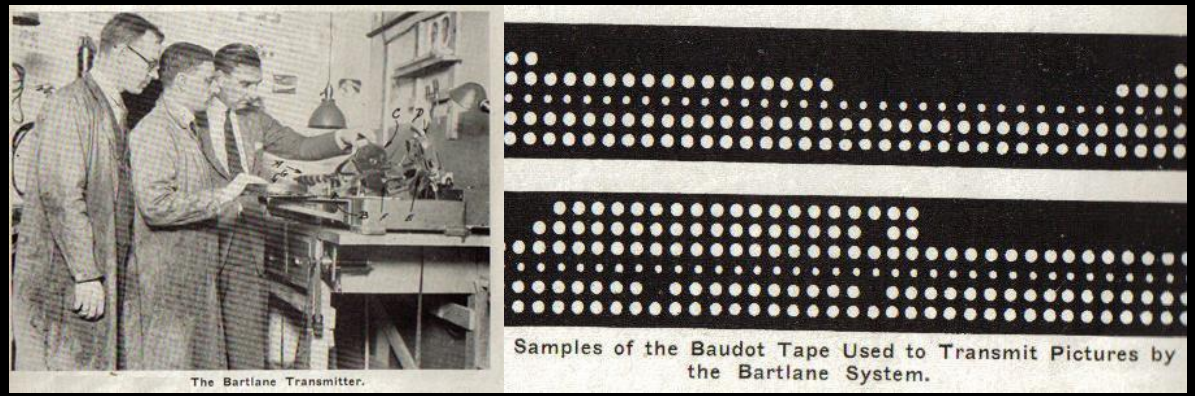
Roteiro

UFV
Universidade Federal de Viçosa

- O sistema Bartlane
- O programa espacial
- O espectro eletromagnético
- Processamento de imagens no Brasil
- Uma aplicação de processamento de imagens
  - Tomografia computadorizada

O sistema Bartlane

- Uma das primeiras aplicações das imagens digitais
- Utilizado para enviar imagens digitais por cabo submarino entre Londres e Nova York.
- Reduziu de mais de uma semana para menos de três horas o tempo necessário para transportar uma fotografia pelo oceano Atlântico.
- Um equipamento codificava as imagens para a transmissão a cabo e depois as reconstruía no recebimento.
- Não ocorria o processamento das imagens

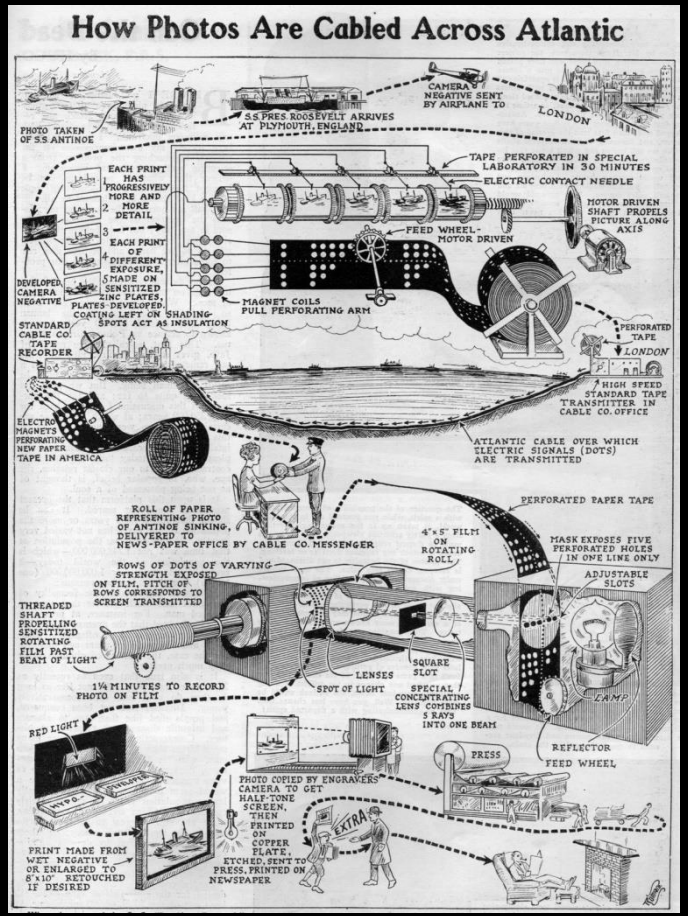


The Bartlane Transmitter.

Samples of the Baudot Tape Used to Transmit Pictures by the Bartlane System.

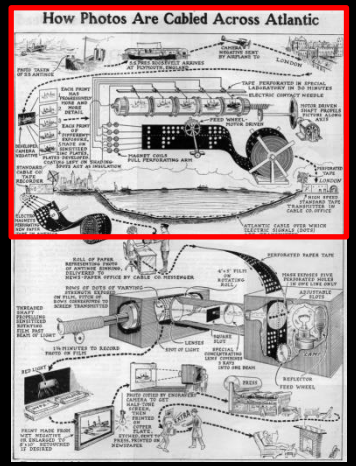
http://www.hffax.de/history/html/bartlane.html

O sistema Bartlane

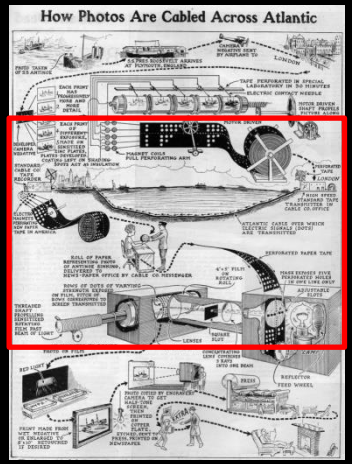


Infográfico publicado originalmente na edição de abril de 1926 da revista Science and Invention.

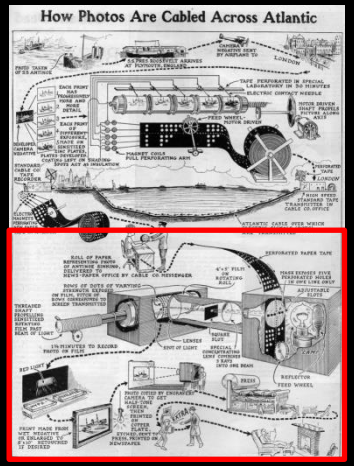
O sistema Bartlane



O sistema Bartlane



O sistema Bartlane



O programa espacial

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- JPL – Jet Propulsion Lab (Pasadena, Califórnia), 1964

- Ranger 7
  - Sonda espacial Ranger enviada para fotografar a Lua
  - Imagens eram obtidas por câmeras de televisão
  - Enviadas para a Terra por ondas de rádio
  - Necessidade de processar as imagens
    - Melhorar a qualidade das imagens
    - Obter a maior quantidade de informação possível

- Video Film Converter
  - Desenvolvido para converter os sinais de vídeo analógicos para imagens digitais

- Computador NCR 102D
  - Usado para processar as imagens digitais
  - Ajuste de contraste
  - Normalização da iluminação
  - Remoção da imagens residual proveniente de capturas anteriores
  - Remoção de ruído de transmissão
  - Correções geométricas usando marcas reseau.

O programa espacial

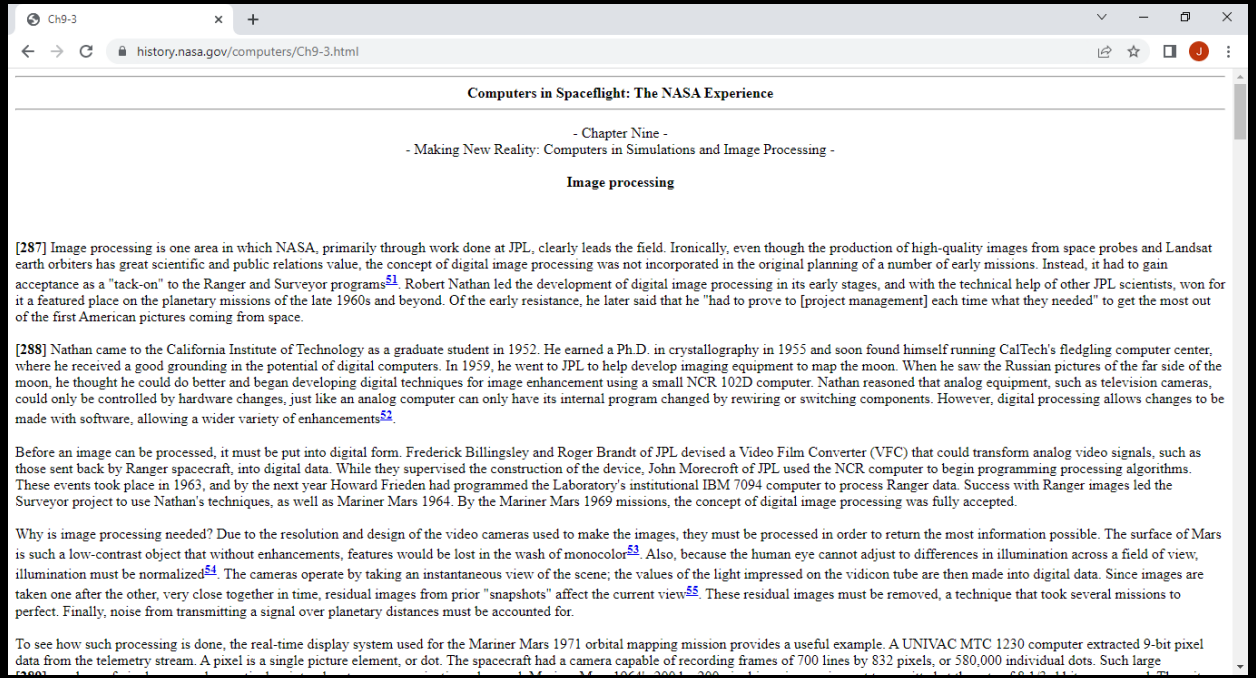
- Primeira imagem da lua tirada pela Ranger 7
- 31 de julho de 1964.
- Cerca de 17 minutos antes do impacto na superfície lunar

A sonda Ranger 7.

https://pt.wikipedia.org/wiki/Ranger_7

O programa espacial

- Computers in Spaceflight: The NASA Experience.
  - Chapter Nine. Making New Reality: Computers in Simulations and Image Processing.
    - https://history.nasa.gov/computers/Ch9-3.html



Ch9-3

history.nasa.gov/computers/Ch9-3.html

Computers in Spaceflight: The NASA Experience

- Chapter Nine -
- Making New Reality: Computers in Simulations and Image Processing -

Image processing

[287] Image processing is one area in which NASA, primarily through work done at JPL, clearly leads the field. Ironically, even though the production of high-quality images from space probes and Landsat earth orbiters has great scientific and public relations value, the concept of digital image processing was not incorporated in the original planning of a number of early missions. Instead, it had to gain acceptance as a "tack-on" to the Ranger and Surveyor programs[51]. Robert Nathan led the development of digital image processing in its early stages, and with the technical help of other JPL scientists, won for it a featured place on the planetary missions of the late 1960s and beyond. Of the early resistance, he later said that he "had to prove to [project management] each time what they needed" to get the most out of the first American pictures coming from space.

[288] Nathan came to the California Institute of Technology as a graduate student in 1952. He earned a Ph.D. in crystallography in 1955 and soon found himself running CalTech's fledgling computer center, where he received a good grounding in the potential of digital computers. In 1959, he went to JPL to help develop imaging equipment to map the moon. When he saw the Russian pictures of the far side of the moon, he thought he could do better and began developing digital techniques for image enhancement using a small NCR 102D computer. Nathan reasoned that analog equipment, such as television cameras, could only be controlled by hardware changes, just like an analog computer can only have its internal program changed by rewiring or switching components. However, digital processing allows changes to be made with software, allowing a wider variety of enhancements[52].

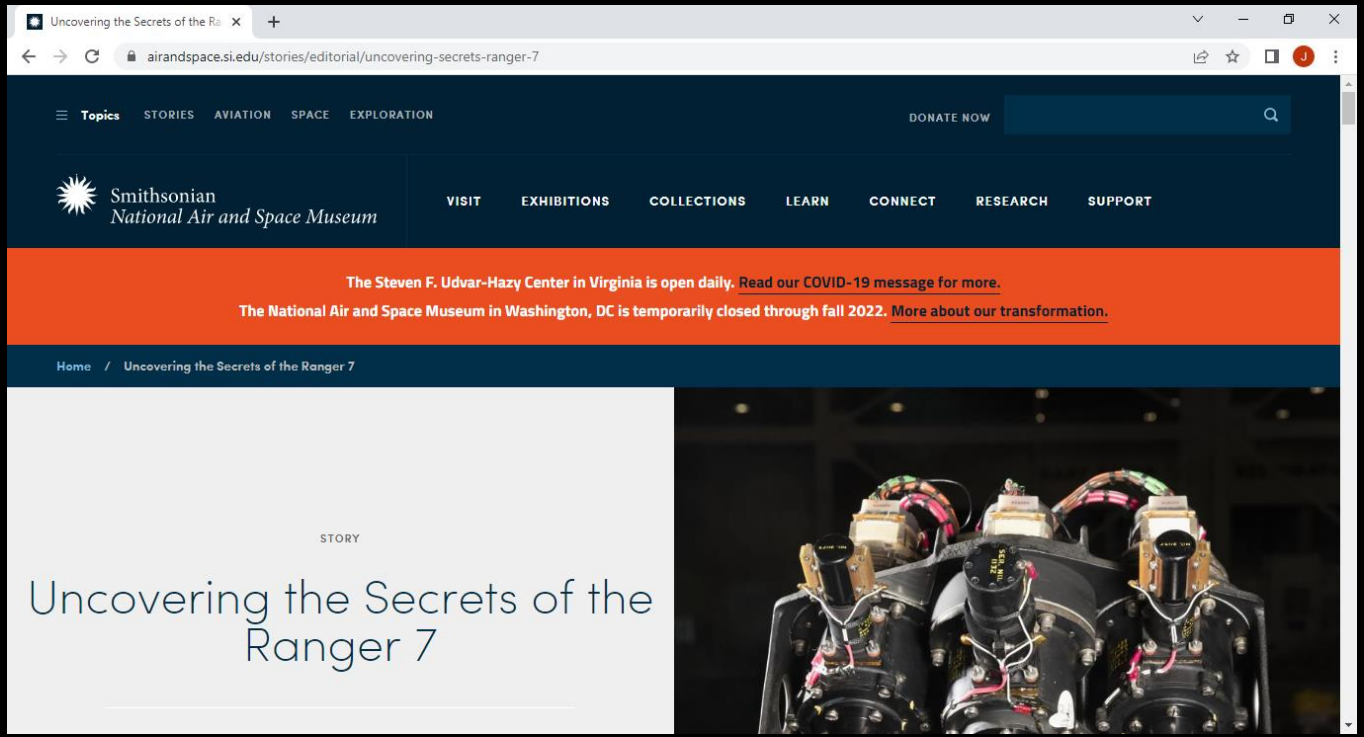
Before an image can be processed, it must be put into digital form. Frederick Billingsley and Roger Brandt of JPL devised a Video Film Converter (VFC) that could transform analog video signals, such as those sent back by Ranger spacecraft, into digital data. While they supervised the construction of the device, John Morecroft of JPL used the NCR computer to begin programming processing algorithms. These events took place in 1963, and by the next year Howard Frieden had programmed the Laboratory's institutional IBM 7094 computer to process Ranger data. Success with Ranger images led the Surveyor project to use Nathan's techniques, as well as Mariner Mars 1964. By the Mariner Mars 1969 missions, the concept of digital image processing was fully accepted.

Why is image processing needed? Due to the resolution and design of the video cameras used to make the images, they must be processed in order to return the most information possible. The surface of Mars is such a low-contrast object that without enhancements, features would be lost in the wash of monocolor[53]. Also, because the human eye cannot adjust to differences in illumination across a field of view, illumination must be normalized[54]. The cameras operate by taking an instantaneous view of the scene; the values of the light impressed on the vidicon tube are then made into digital data. Since images are taken one after the other, very close together in time, residual images from prior "snapshots" affect the current view[55]. These residual images must be removed, a technique that took several missions to perfect. Finally, noise from transmitting a signal over planetary distances must be accounted for.

To see how such processing is done, the real-time display system used for the Mariner Mars 1971 orbital mapping mission provides a useful example. A UNIVAC MTC 1230 computer extracted 9-bit pixel data from the telemetry stream. A pixel is a single picture element, or dot. The spacecraft had a camera capable of recording frames of 700 lines by 832 pixels, or 580,000 individual dots. Such large

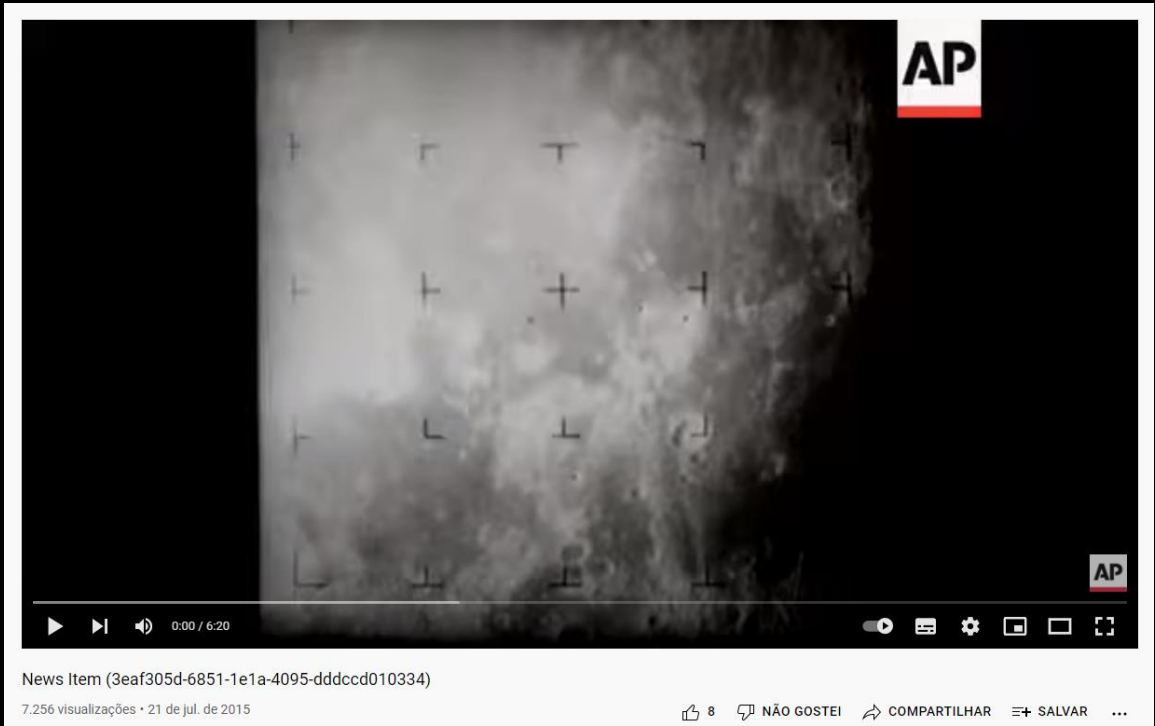
O programa espacial

- Matthew Shindell. Uncovering the Secrets of the Ranger 7. July 31, 2018
  - https://airandspace.si.edu/stories/editorial/uncovering-secrets-ranger-7



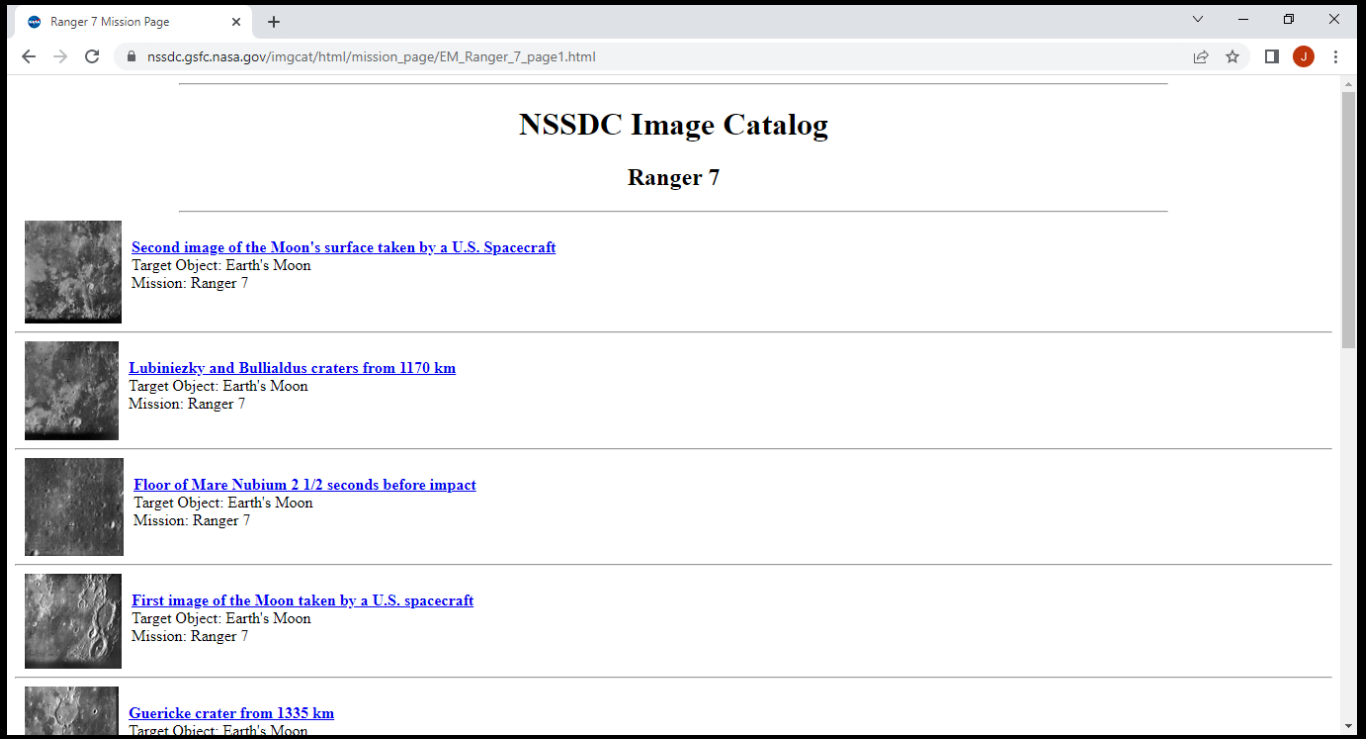
O programa espacial

- US: Ranger 7 - 1964
  - https://www.youtube.com/watch?v=QGJbybcXd0c

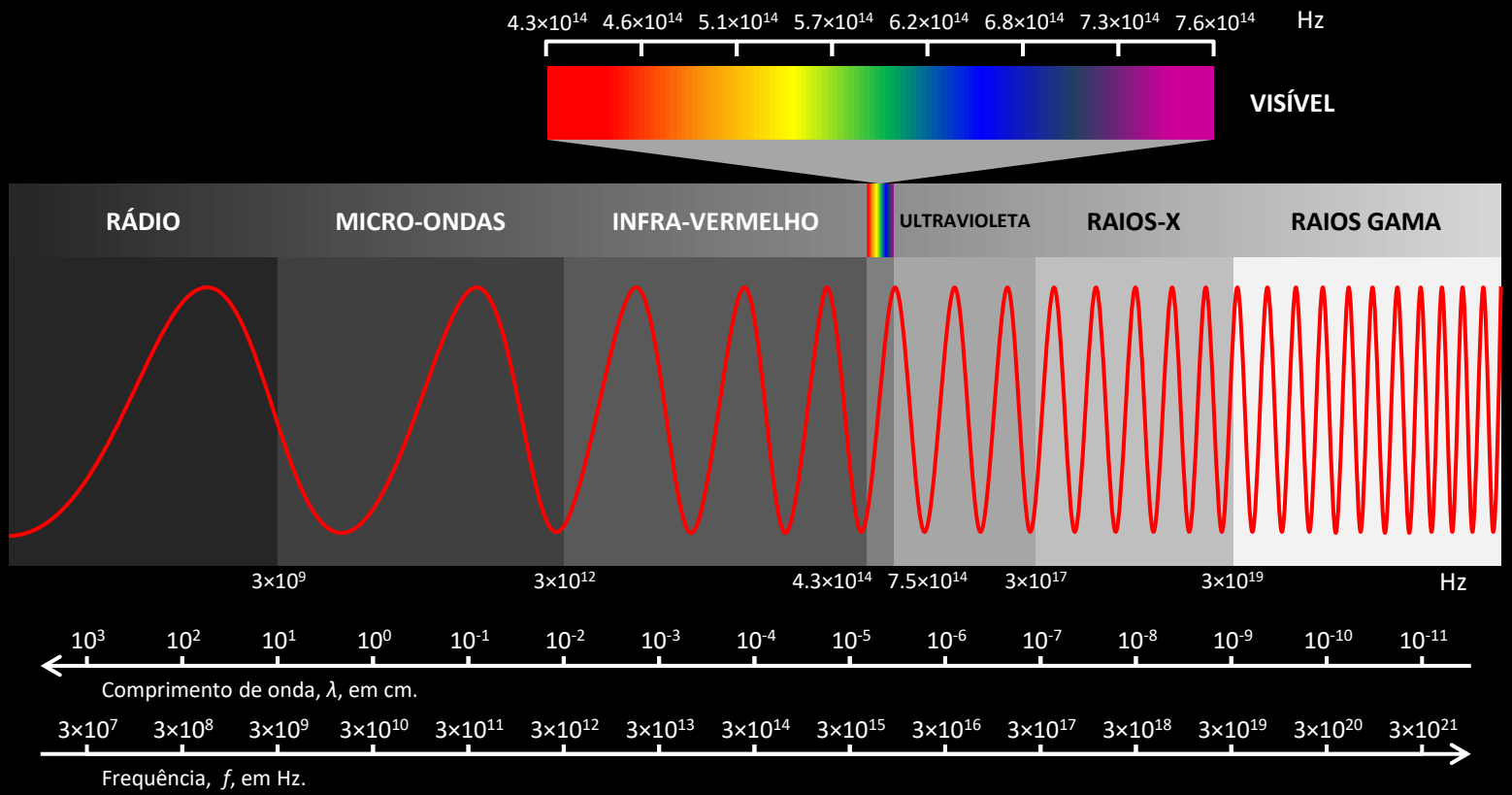


O programa espacial

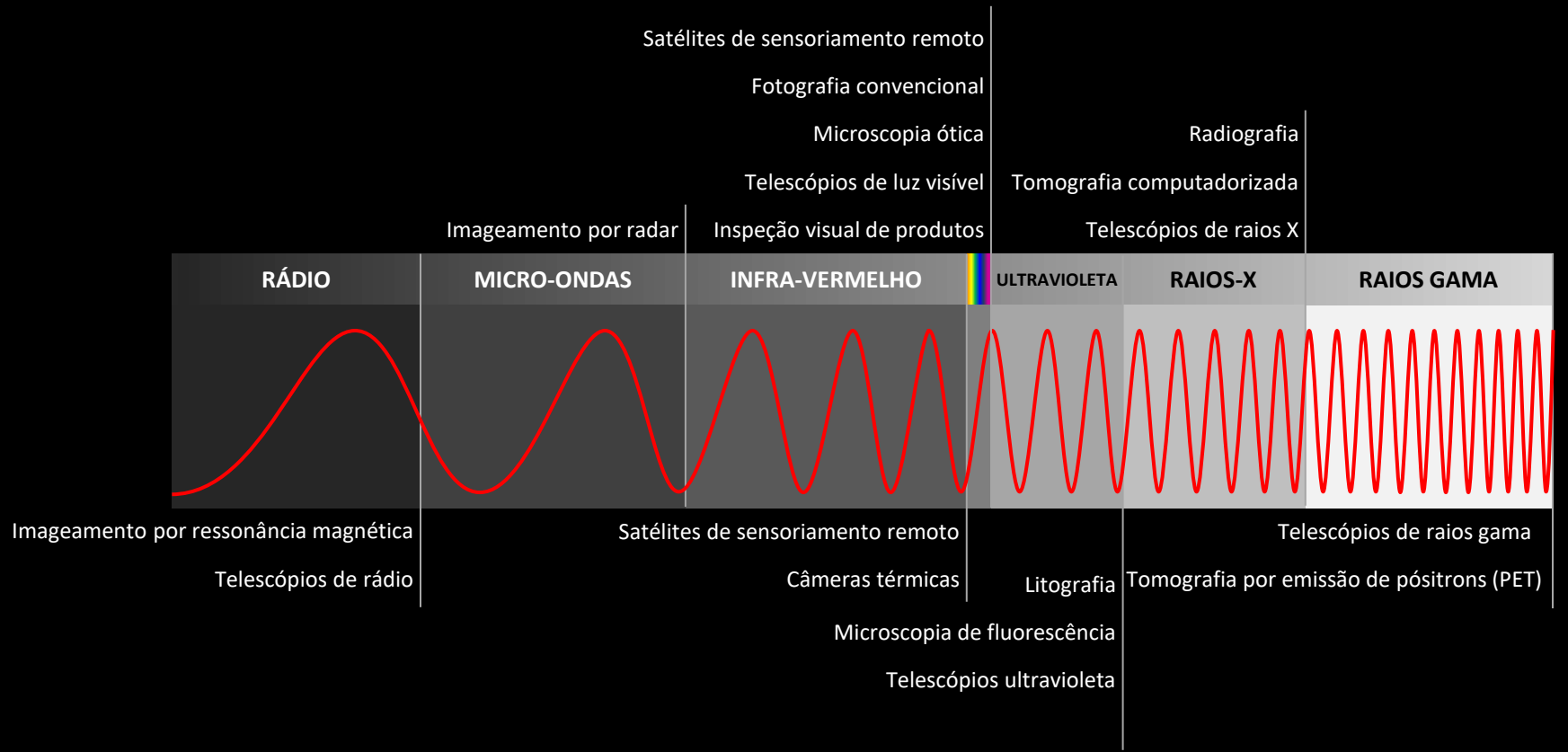
- NSSDC Image Catalog – Ranger 7
  - https://nssdc.gsfc.nasa.gov/imgcat/html/mission_page/EM_Ranger_7_page1.html



O espectro eletromagnético



O espectro eletromagnético



Processamento de imagens no Brasil

- Instituto Nacional de Pesquisas Espaciais – INPE

- GE IMAGE-100, 1974
  - Sistema de Processamento de imagens
  - US$ 1.000.000,00
  - PDP/11-45 com 128 KB de memória
  - Memória de vídeo de 512 x 512 pixels

INPE. http://www.inpe.br/noticias/galeria/

INPE: http://www.dpi.inpe.br/DPI/institucional/pessoal/historico

Processamento de imagens no Brasil

- Instituto Nacional de Pesquisas Espaciais – INPE

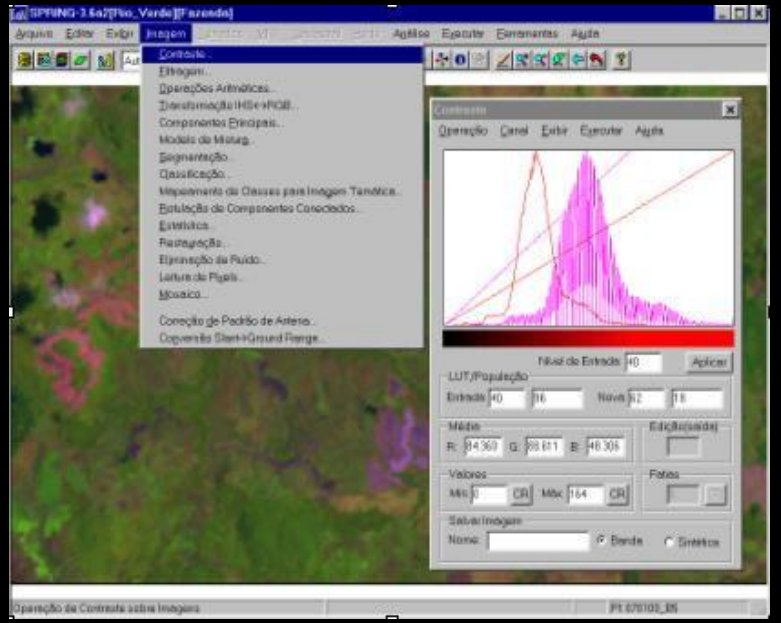
- SITIM – Sistema de Tratamento de Imagens, 1986
  - PC-286 com 8 MHz e 256 Kb de memória
  - Placa gráfica desenvolvida localmente
  - Imagens com até 1024 x 1024 pixels e 24 bits por pixel
  - MS-DOS

INPE: http://www.dpi.inpe.br/DPI/institucional/pessoal/historico

Processamento de imagens no Brasil

- Instituto Nacional de Pesquisas Espaciais – INPE

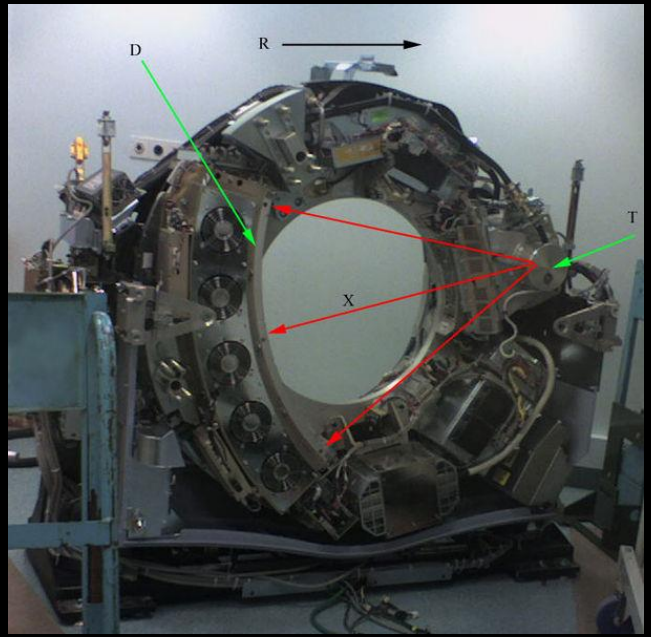
- SPRING – Sistema Integrado de Geoprocessamento e Processamento de Imagens, 1991
  - Interface Gráfica
  - Atualmente disponível para download
    - http://www.dpi.inpe.br/spring/



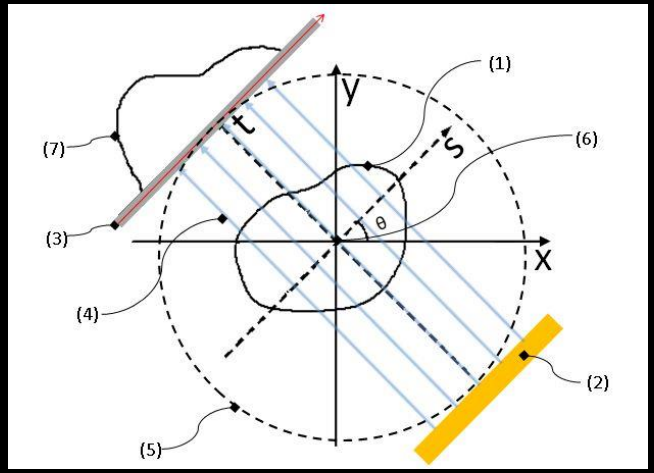
INPE: http://www.dpi.inpe.br/DPI/institucional/pessoal/historico

Uma aplicação de processamento de imagens

- Tomografia computadorizada
  - Allan Cormack e Newbold Hounsfield (1972)



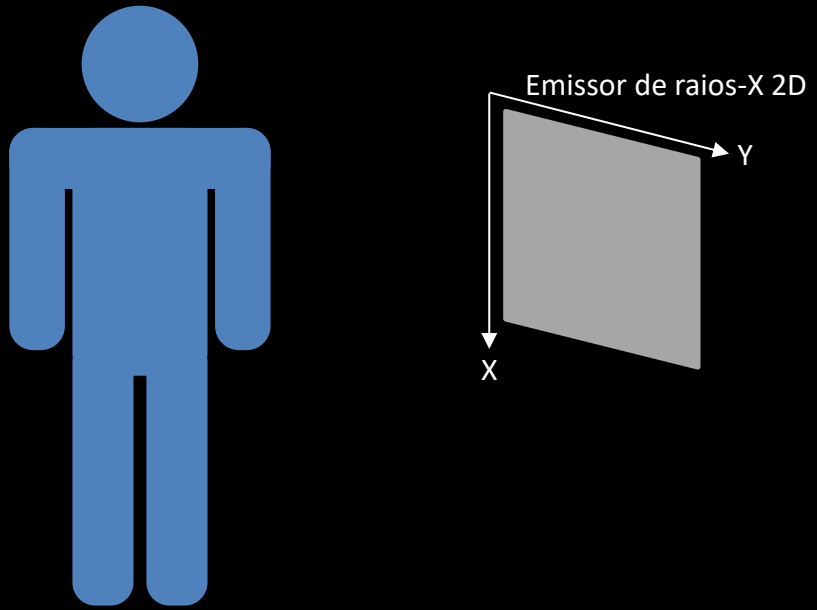
https://pt.wikipedia.org/wiki/Tomografia_computadorizada



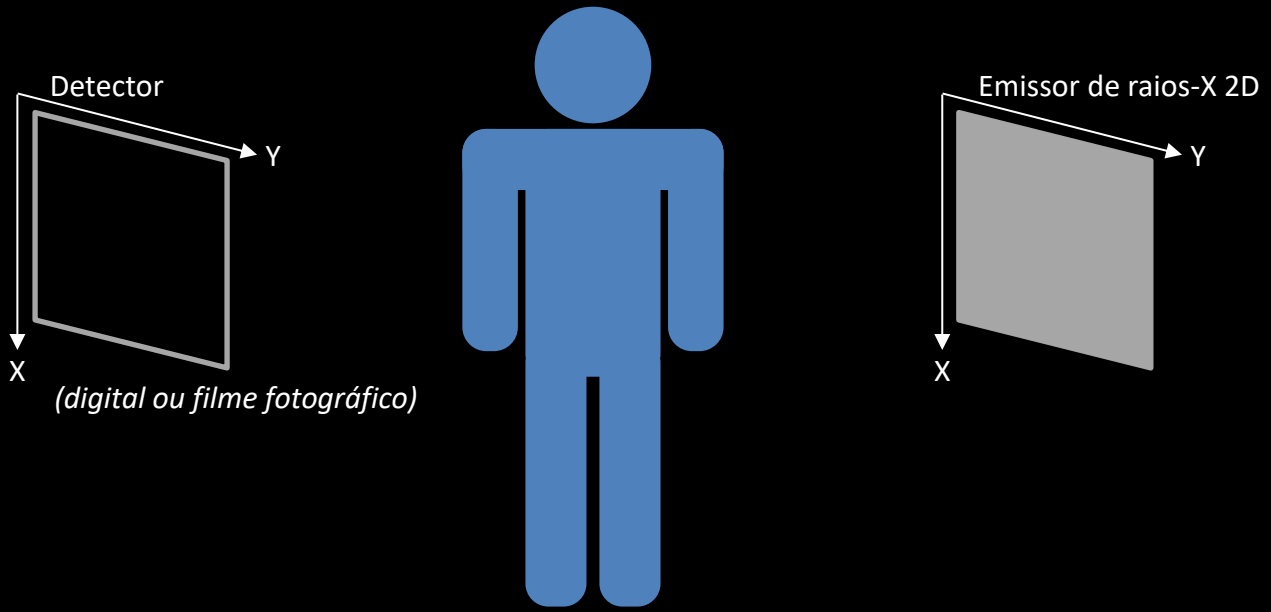
https://pt.wikipedia.org/wiki/Transformada_de_Radon

1. Objeto radiografado;
2. Emissor de raios X;
3. Sensor;
4. Feixe de raios que atravessa o objeto, sofrendo uma atenuação;
5. Limites do aparelho;
6. Origem dos sistemas de referência;
7. Medida obtida no detector.

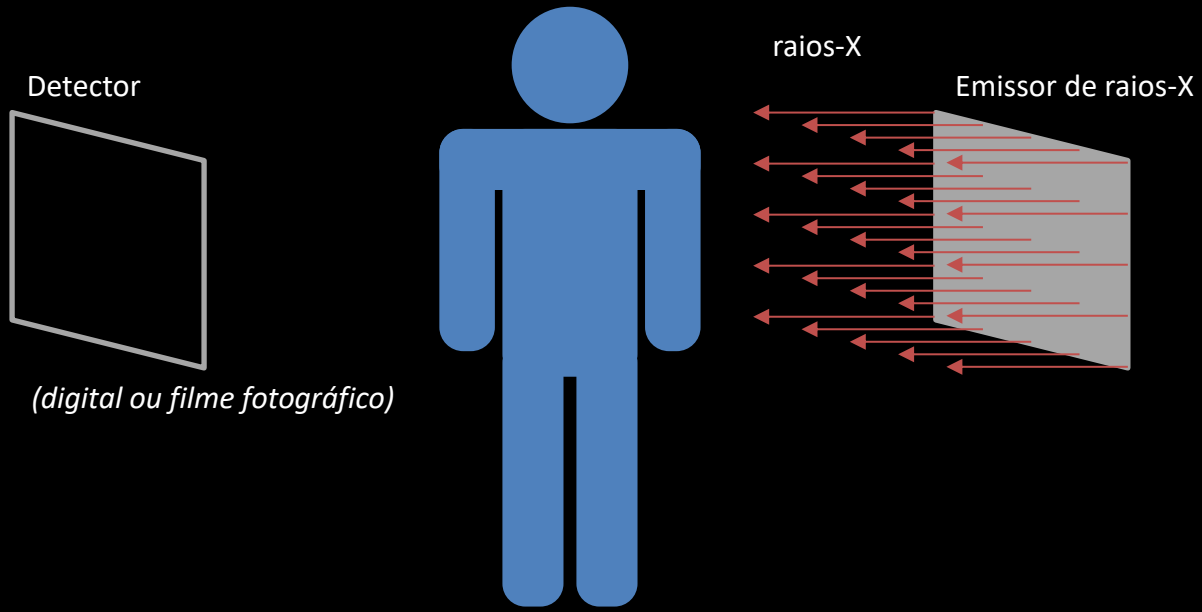
Raio-X



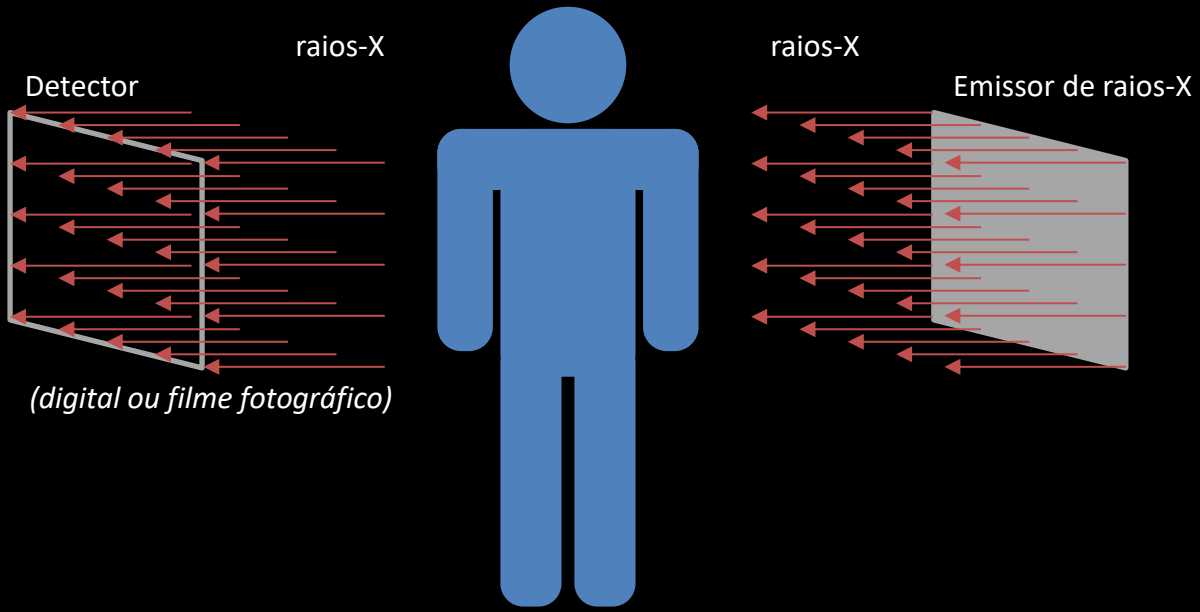
Raio-X


Detector
Y
X
(digital ou filme fotográfico)
Emissor de raios-X 2D
Y
X

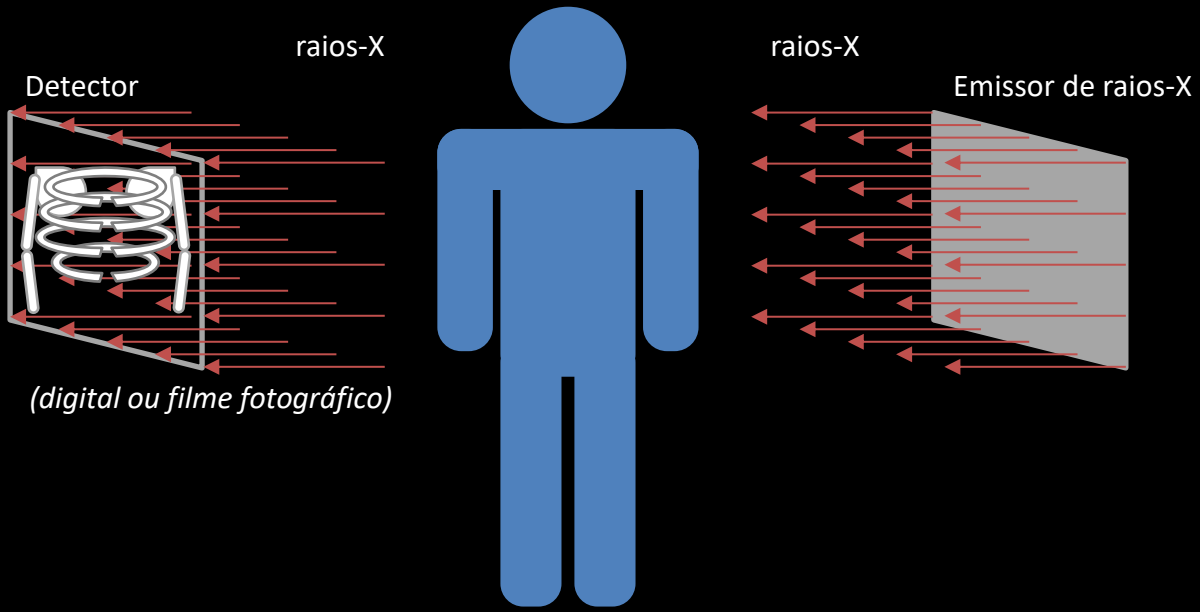
Raio-X


Detector
(digital ou filme fotográfico)
raios-X
Emissor de raios-X

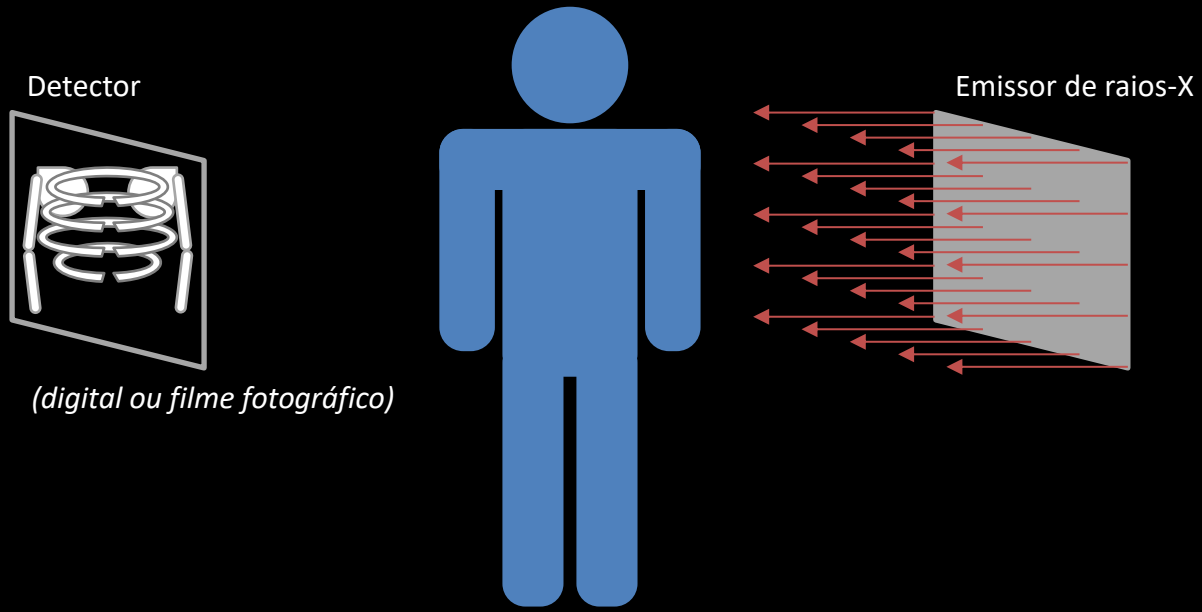
Raio-X


raios-X
Detector
raios-X
Emissor de raios-X
(digital ou filme fotográfico)

Raio-X

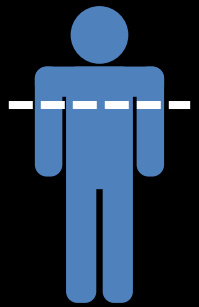

raios-X
Detector
raios-X
Emissor de raios-X
(digital ou filme fotográfico)

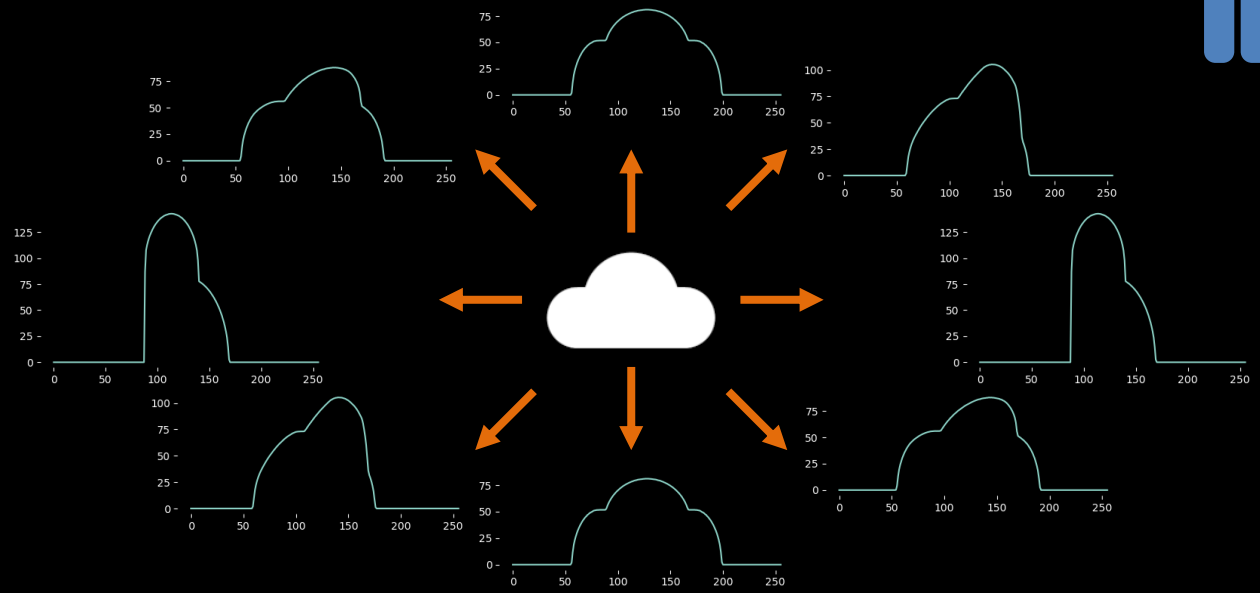
Raio-X

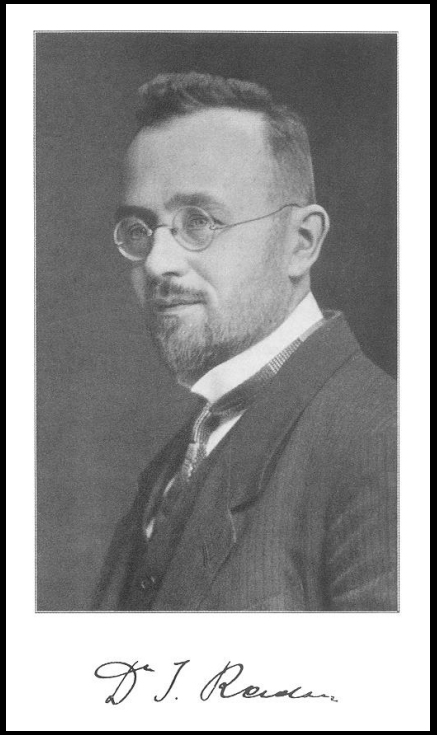


Tomografia computadorizada

- A Transformada de Radon
  - Johann Radon (1917)
  - Reconstrução de funções a partir de projeções

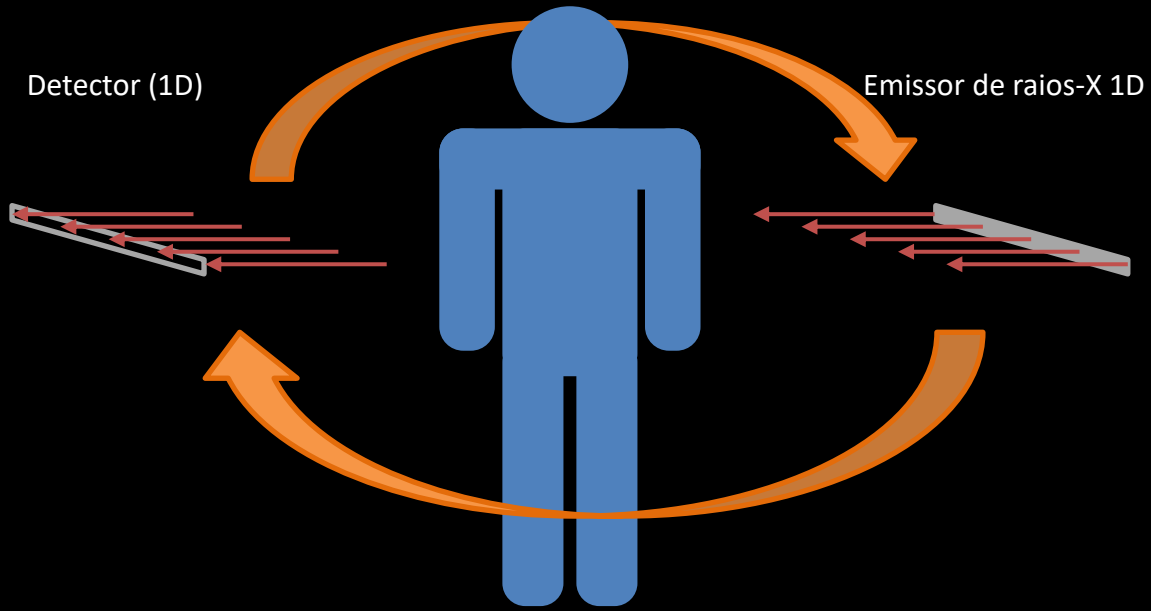






https://pt.wikipedia.org/wiki/Johann_Radon

Tomografia computadorizada



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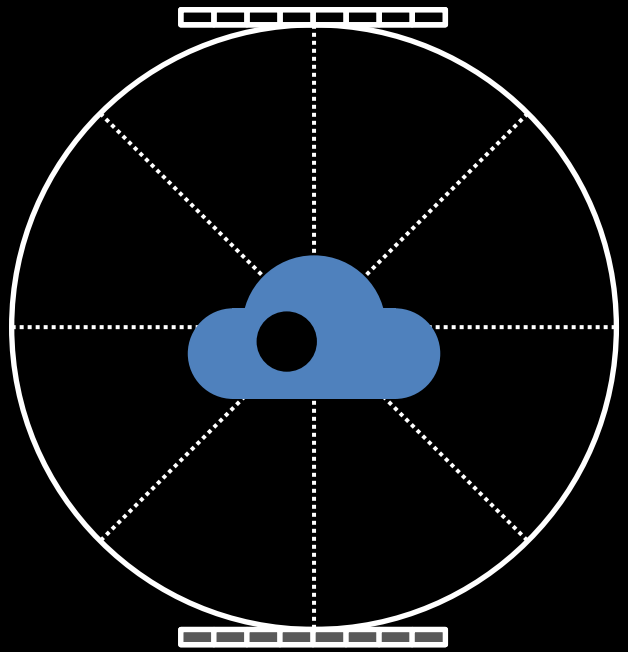

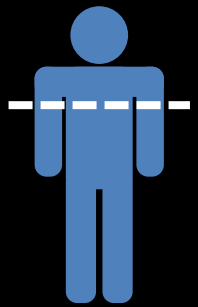

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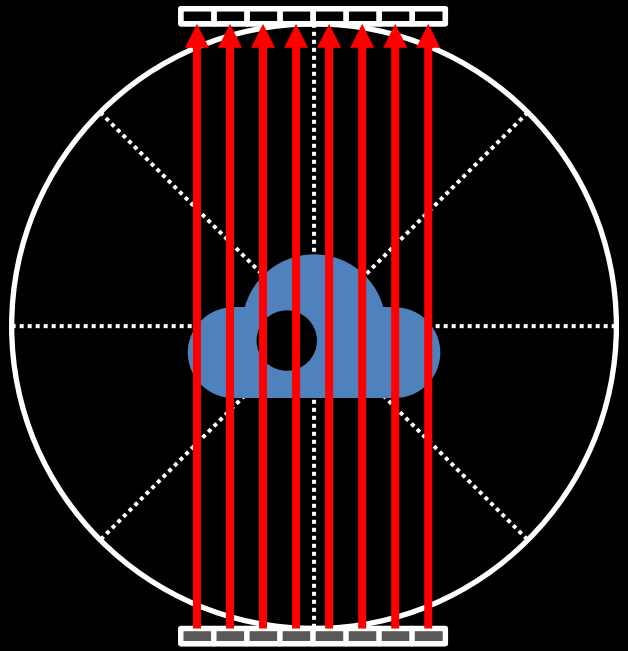
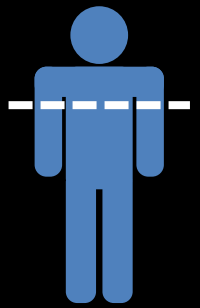
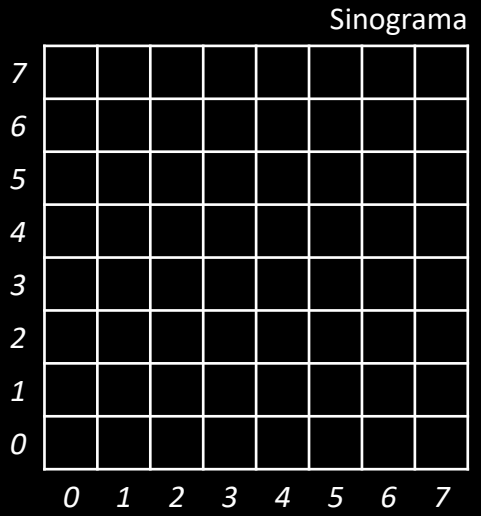
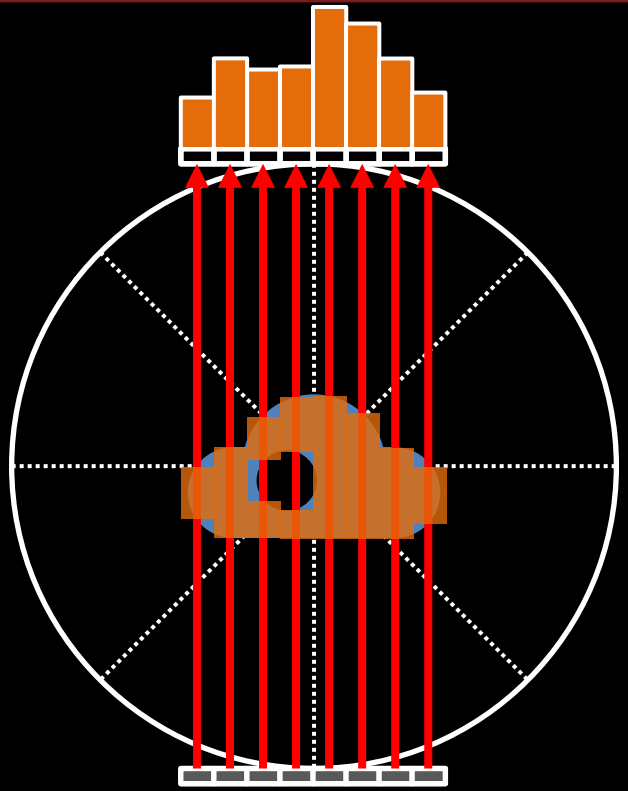
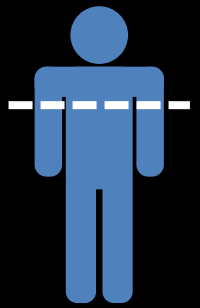




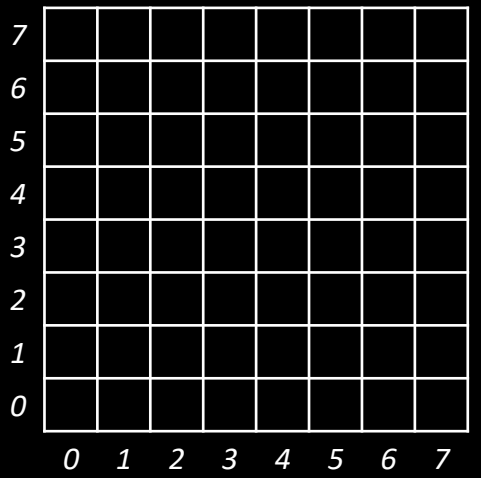


Tomografia computadorizada

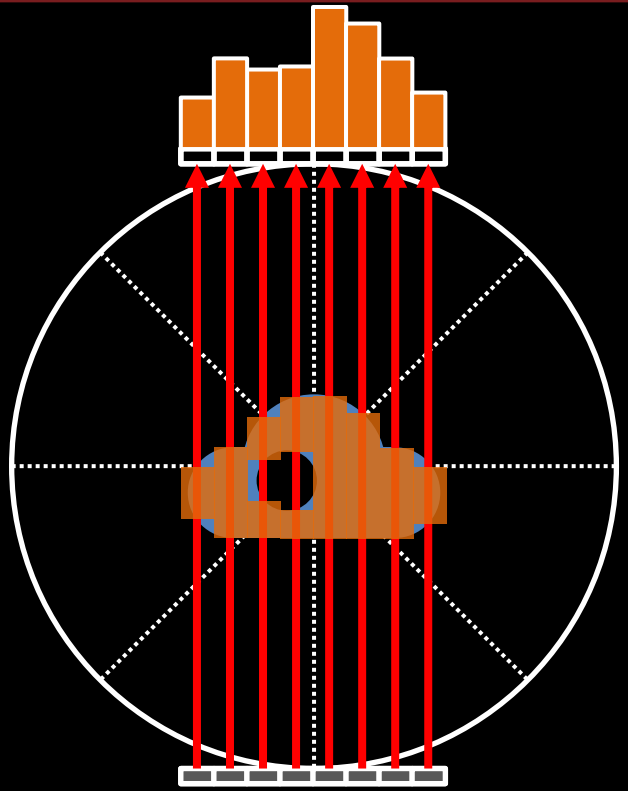


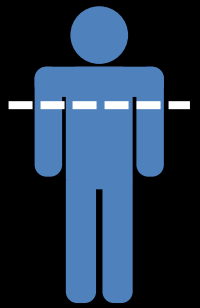


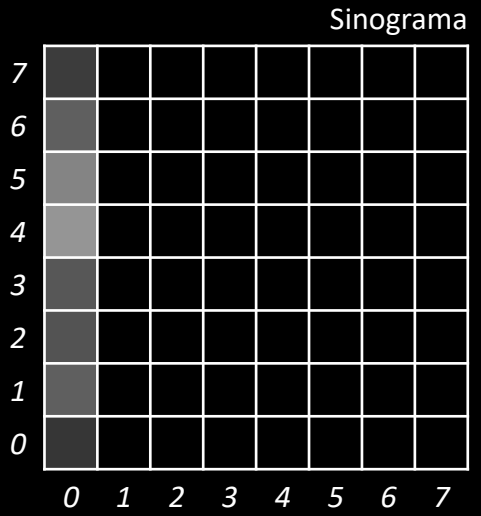
Sinograma



Tomografia computadorizada







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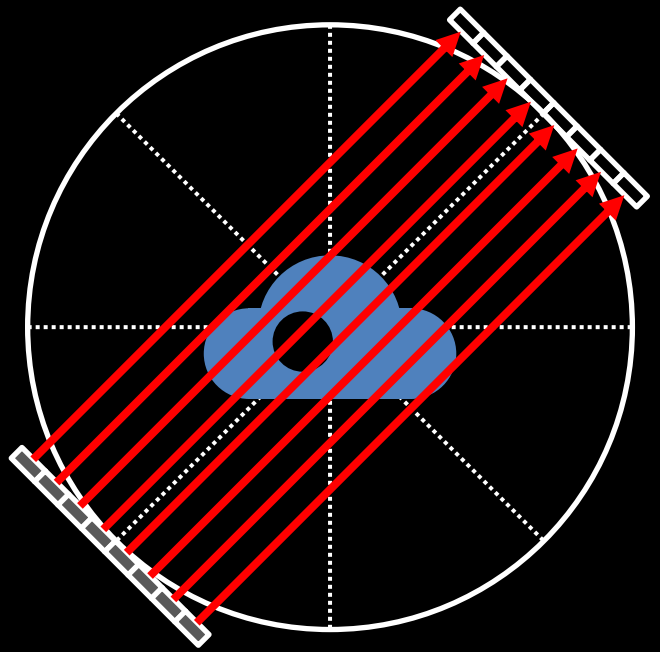

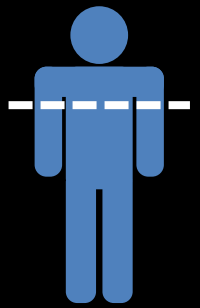

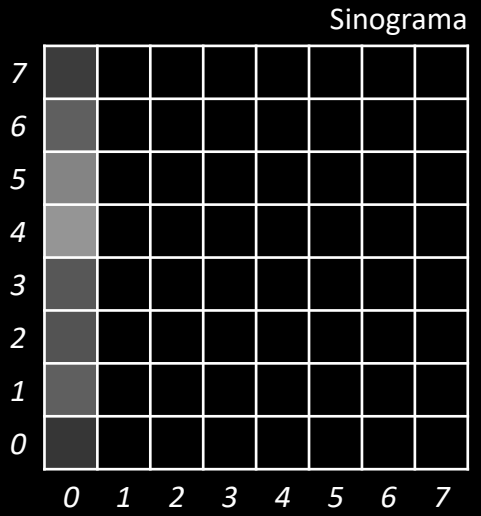

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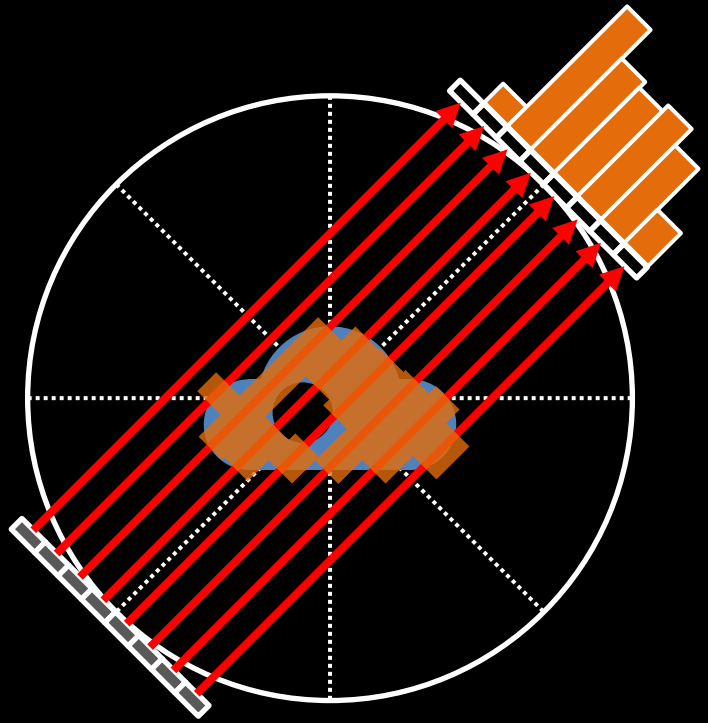
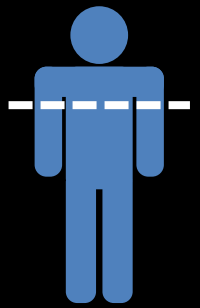
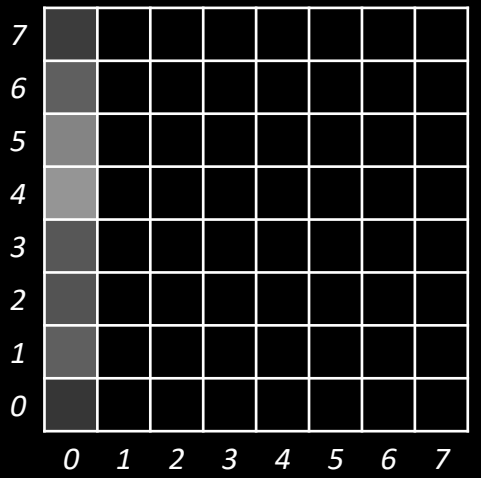
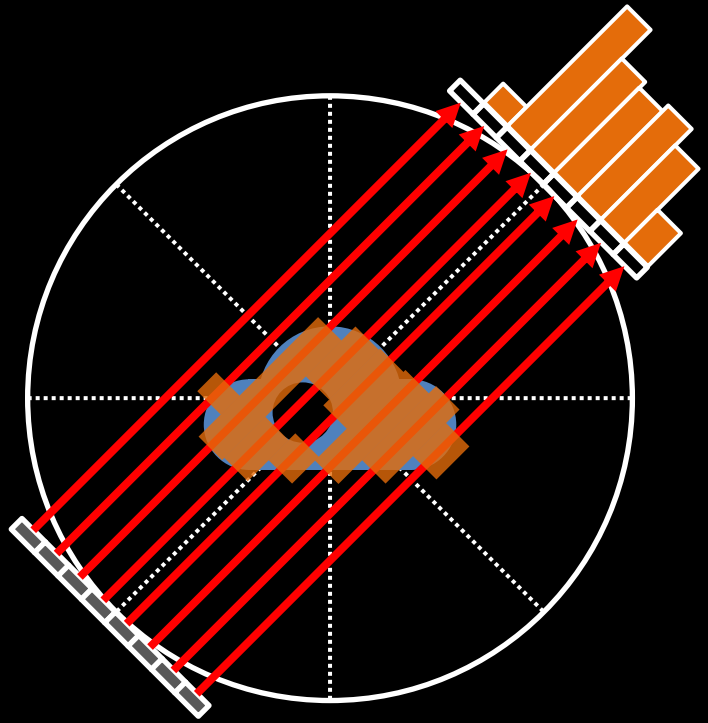


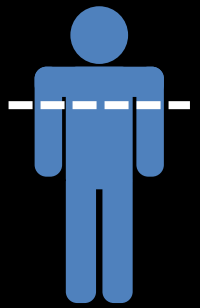


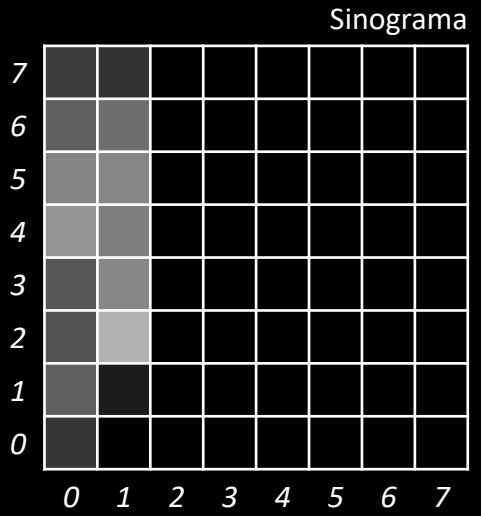
Sinograma



Tomografia computadorizada







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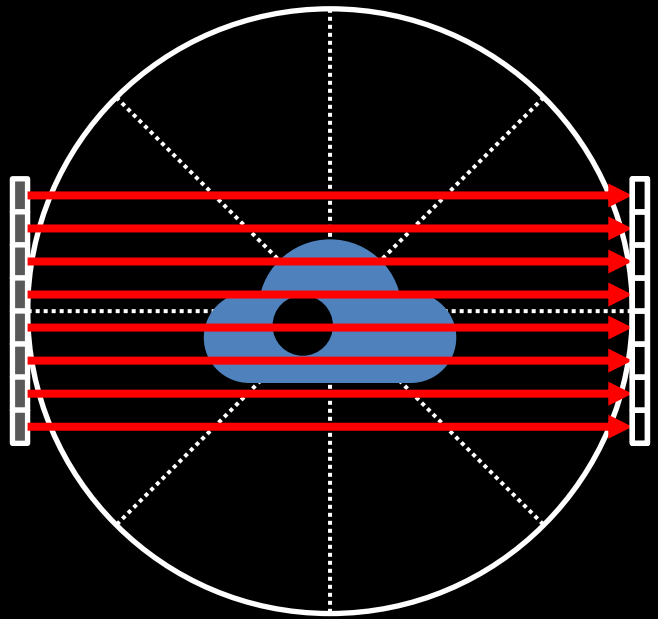

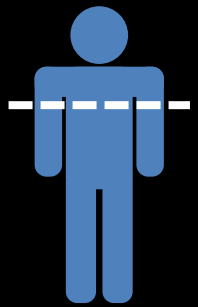

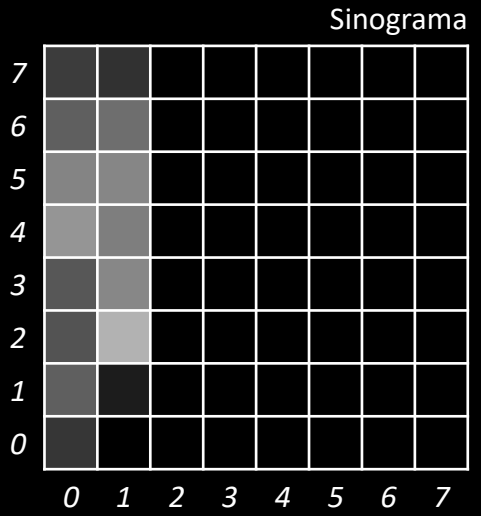

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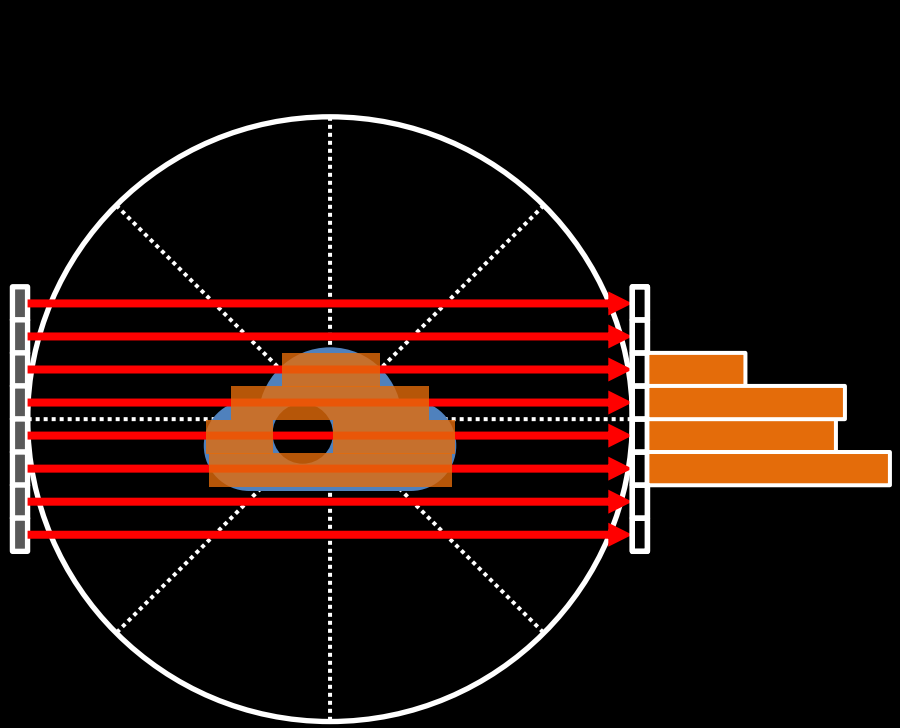

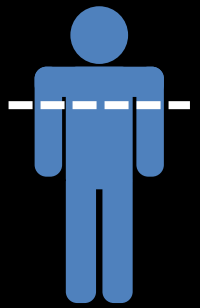

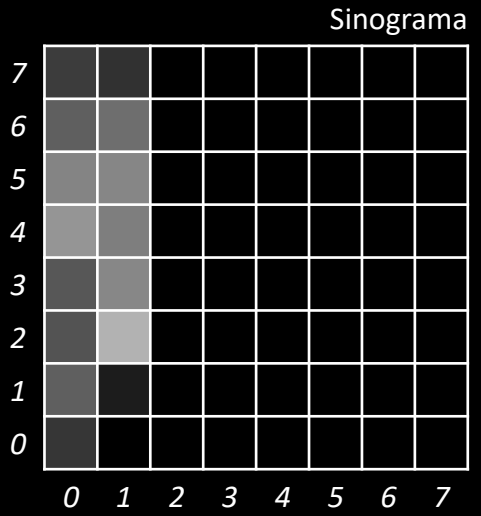

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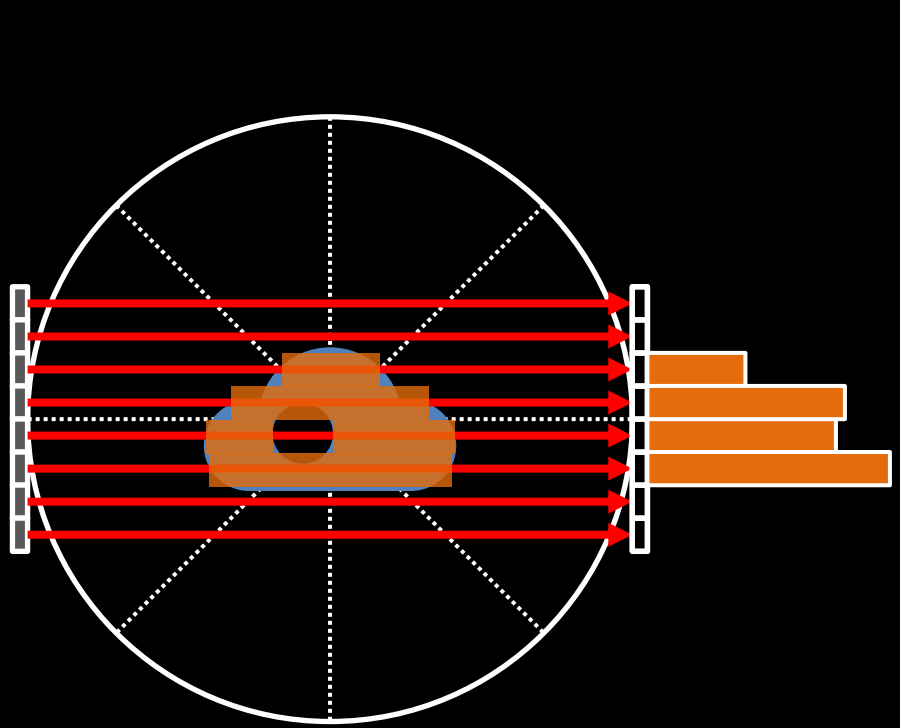

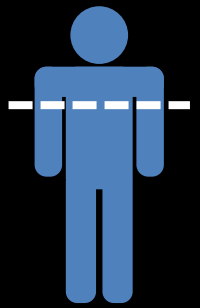

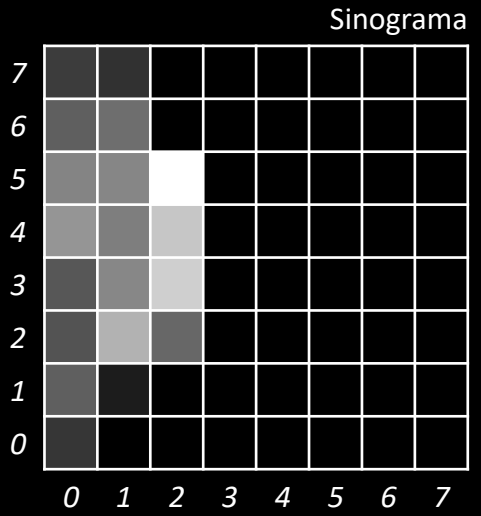

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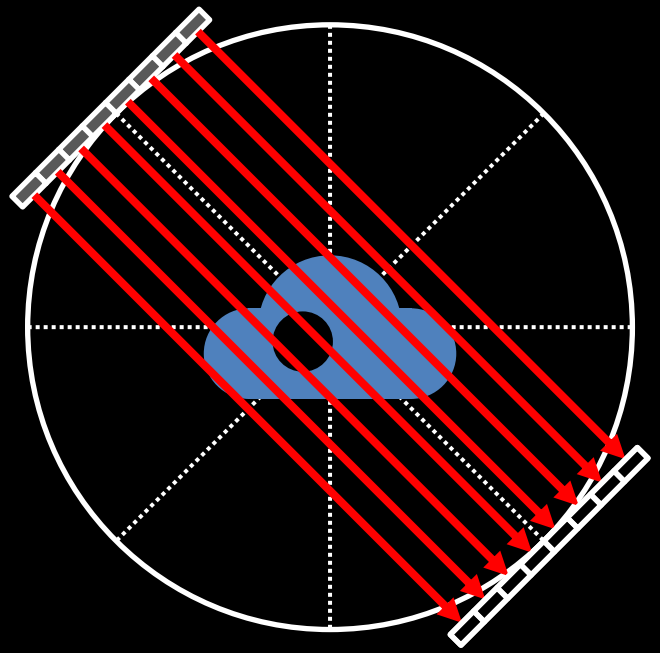

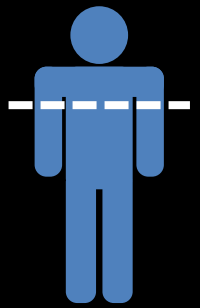

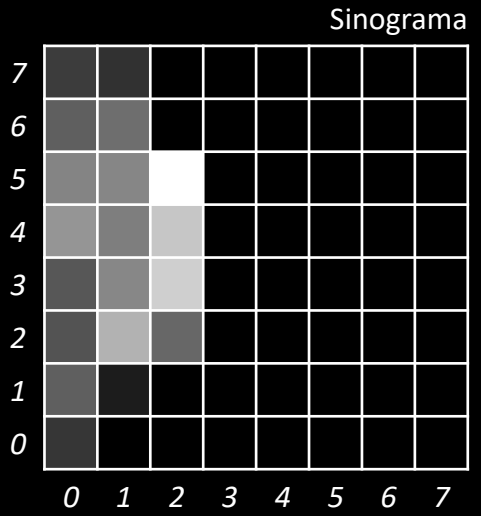

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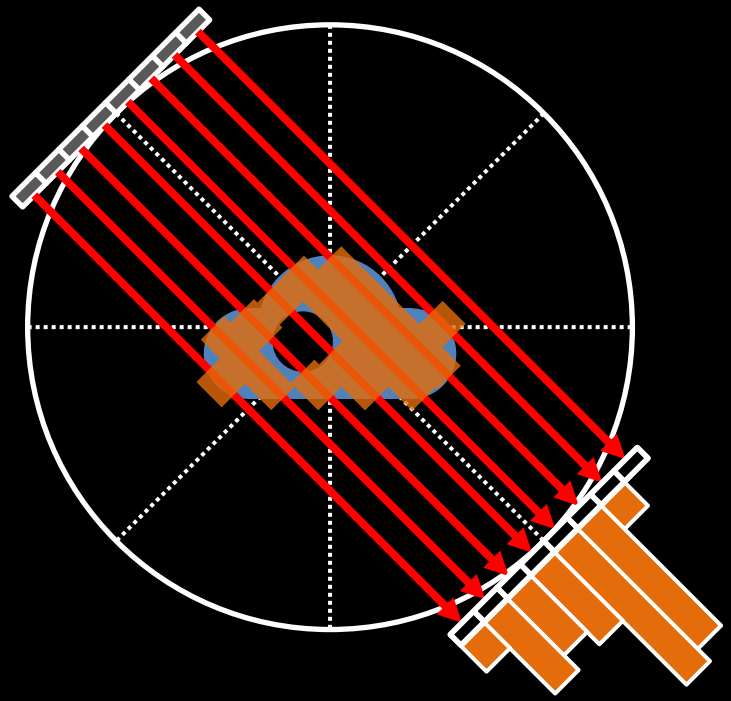

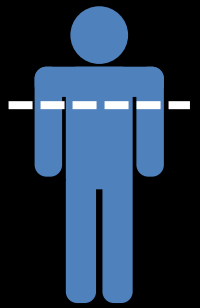

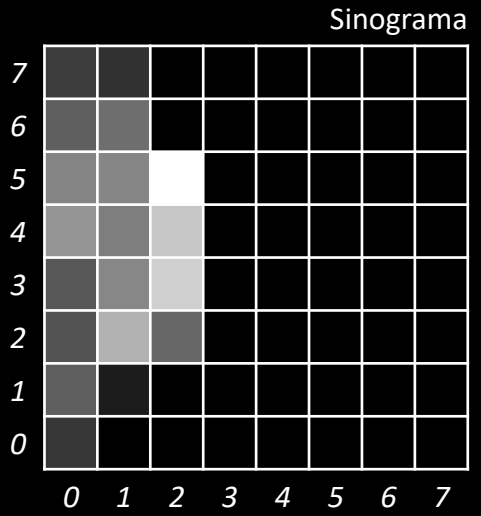

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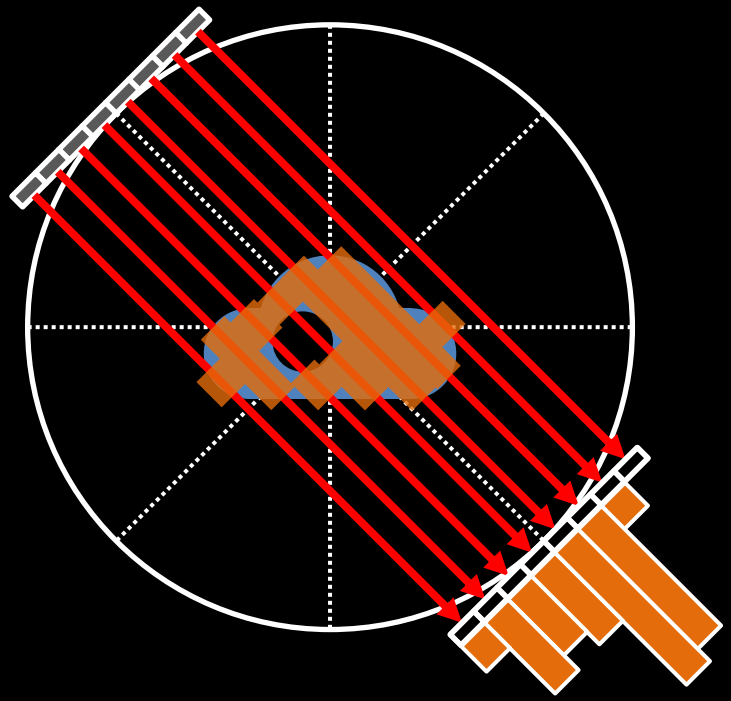

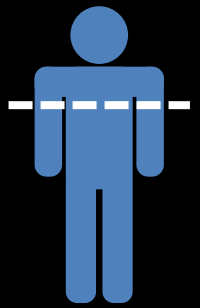

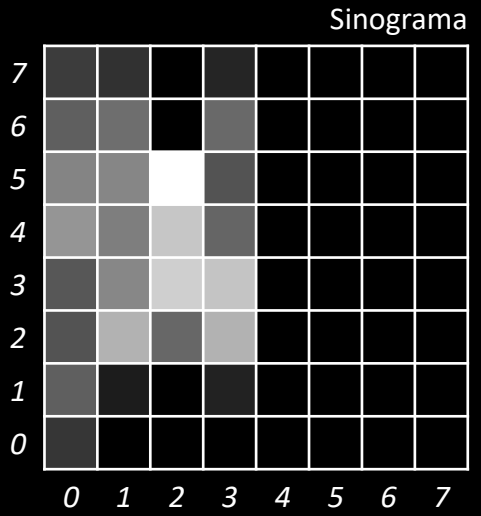

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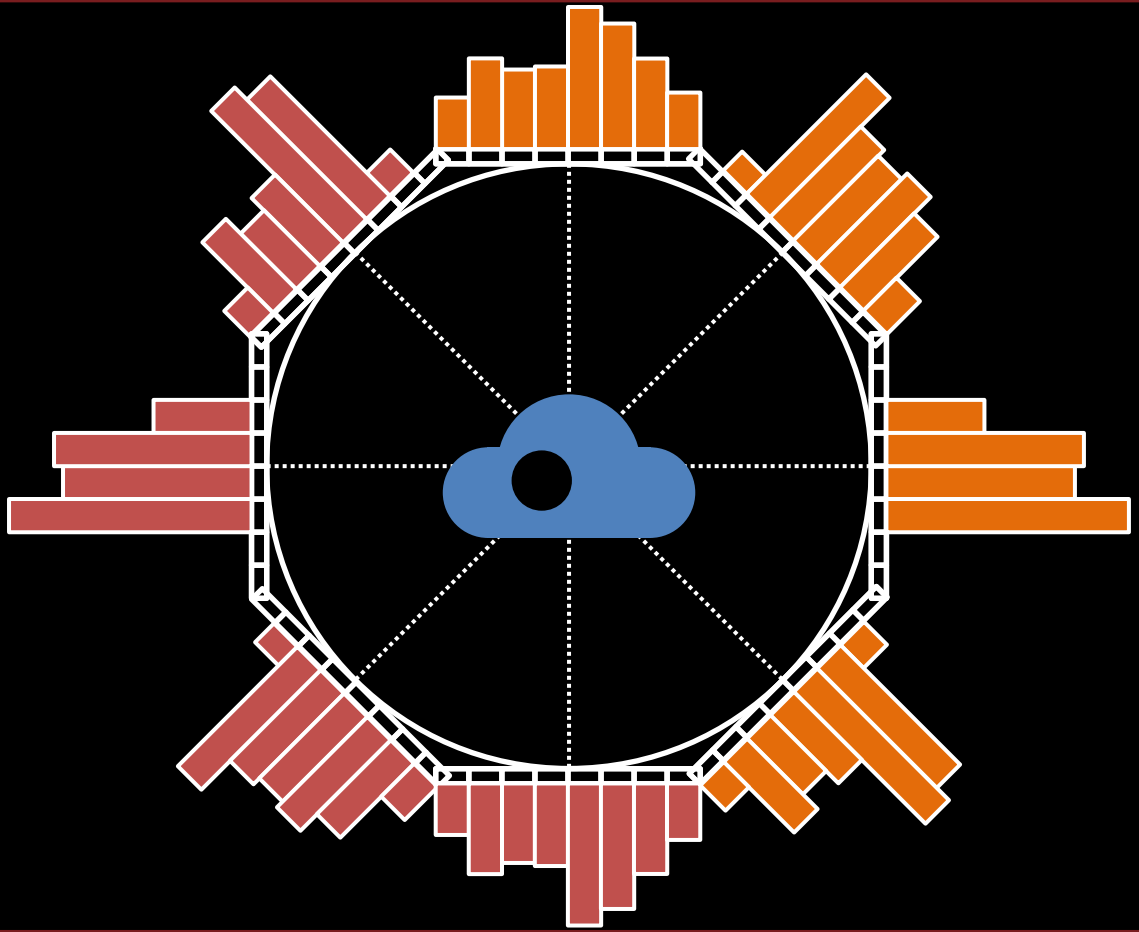

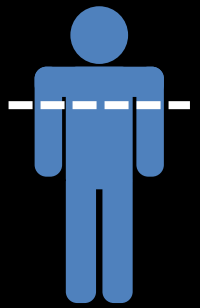

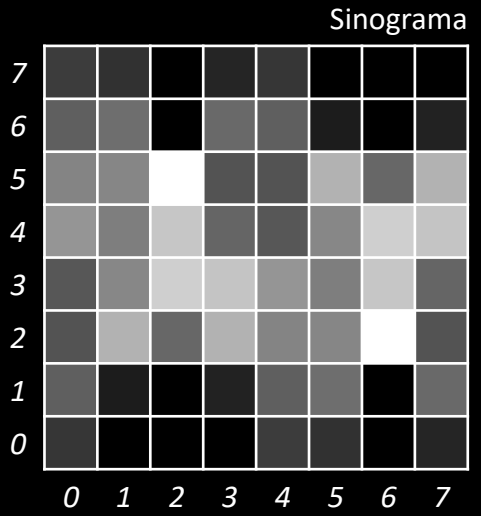

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