Image Reconstruction Introduction

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Steps of Machine Vision

- Image acquisition
- Preprocessing
- Segmentation
- Feature extraction
- Classification, interpretation
- Actuation

Image Acquisition

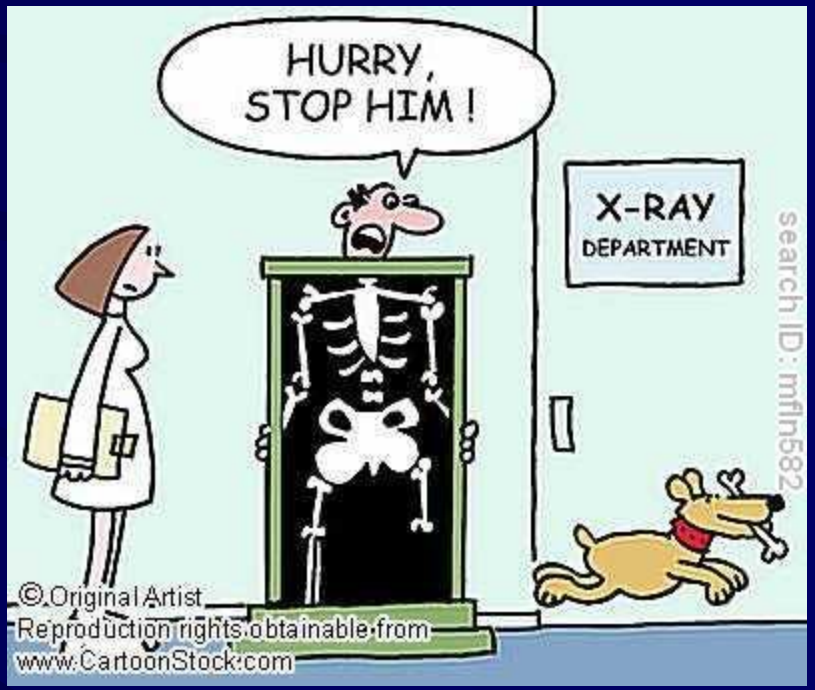
by visible light

by X-rays

X-rays

- 1895 - Wilhelm Conrad Röntgen describes the properties of X-rays
- Kind of electromagnetic radiation (similar to light but having more energy)
- Attenuation of X-rays depends on tissue → „Shadow” of the object from one direction

X-rays are Useful in Radiology (in some cases)

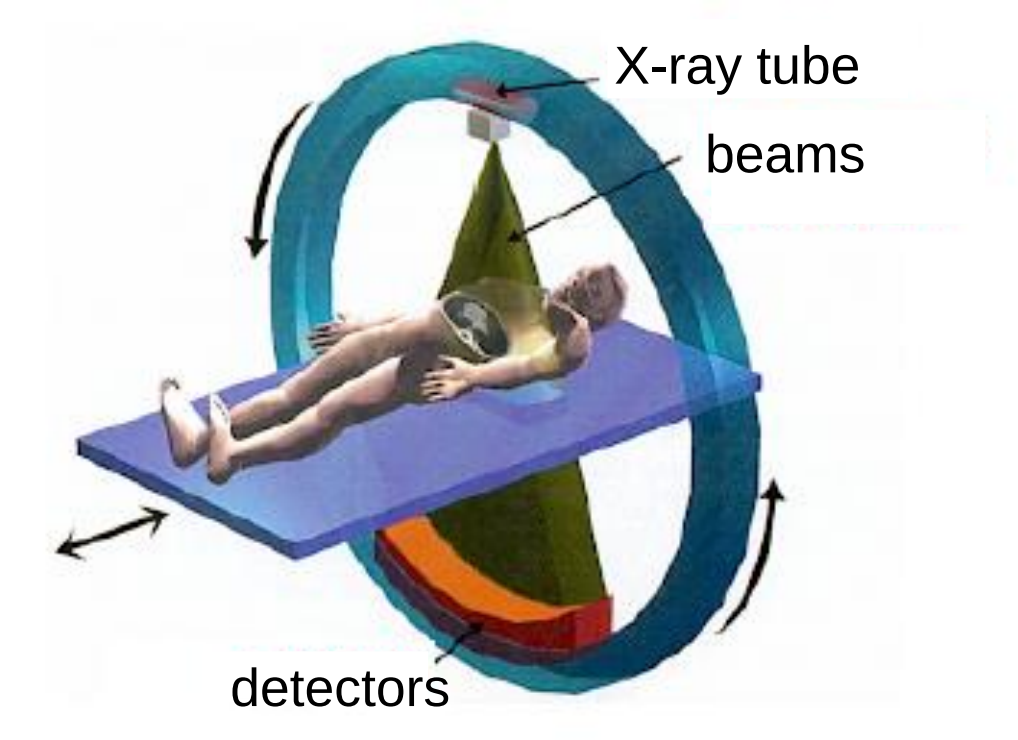


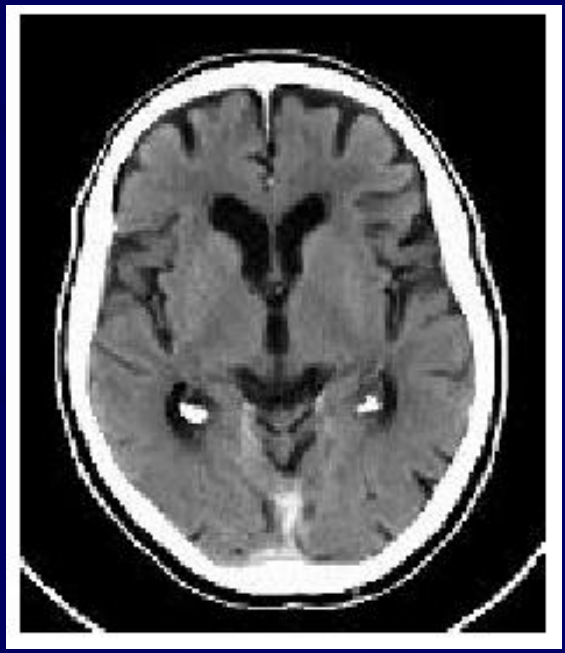
Tomography

Tomos = part, section
Grapho = to write
Tomos + Grapho ≈ imaging by cross-sections (slices)

Computerized Tomography

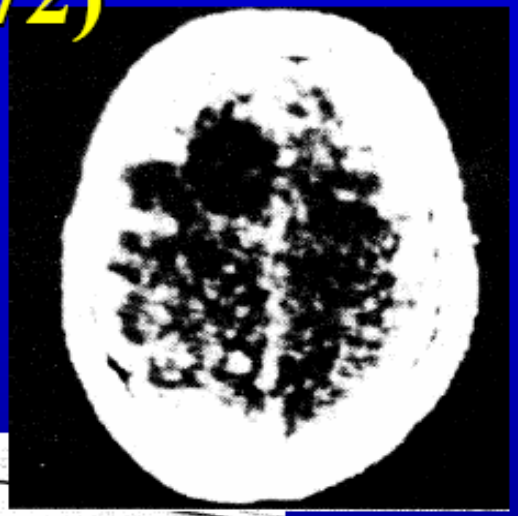
- A technique for imaging the 2D cross-sections of 3D objects (human organs) without seriously damaging them
- Take X-ray images from many angles and combine them in a clever way

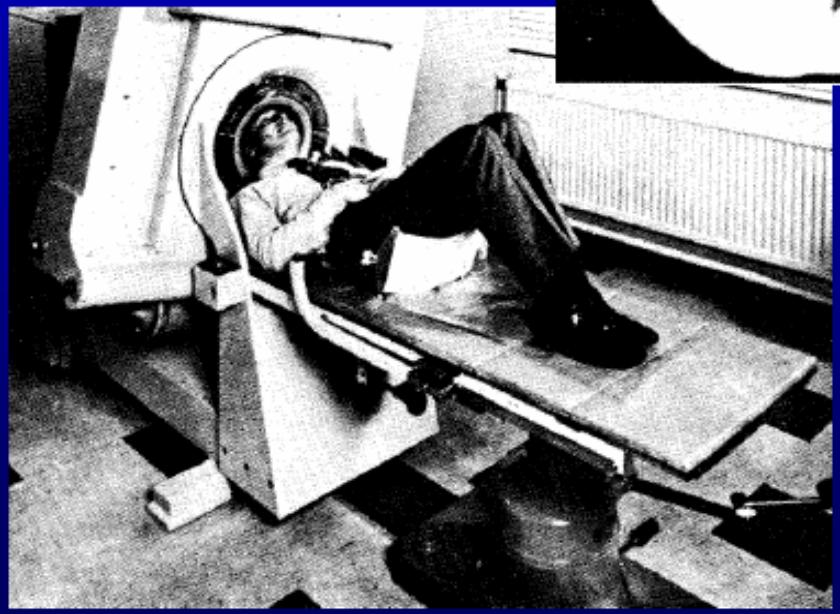




The first CT (1972)

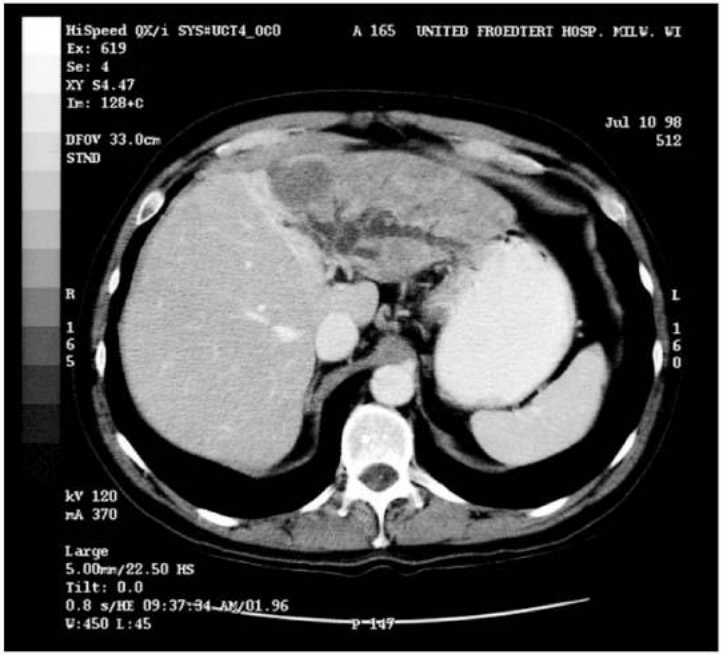
Godfrey N. Hounsfield
Nobel-prize 1979





Slide: Attila Kuba

A Modern CT Scanner

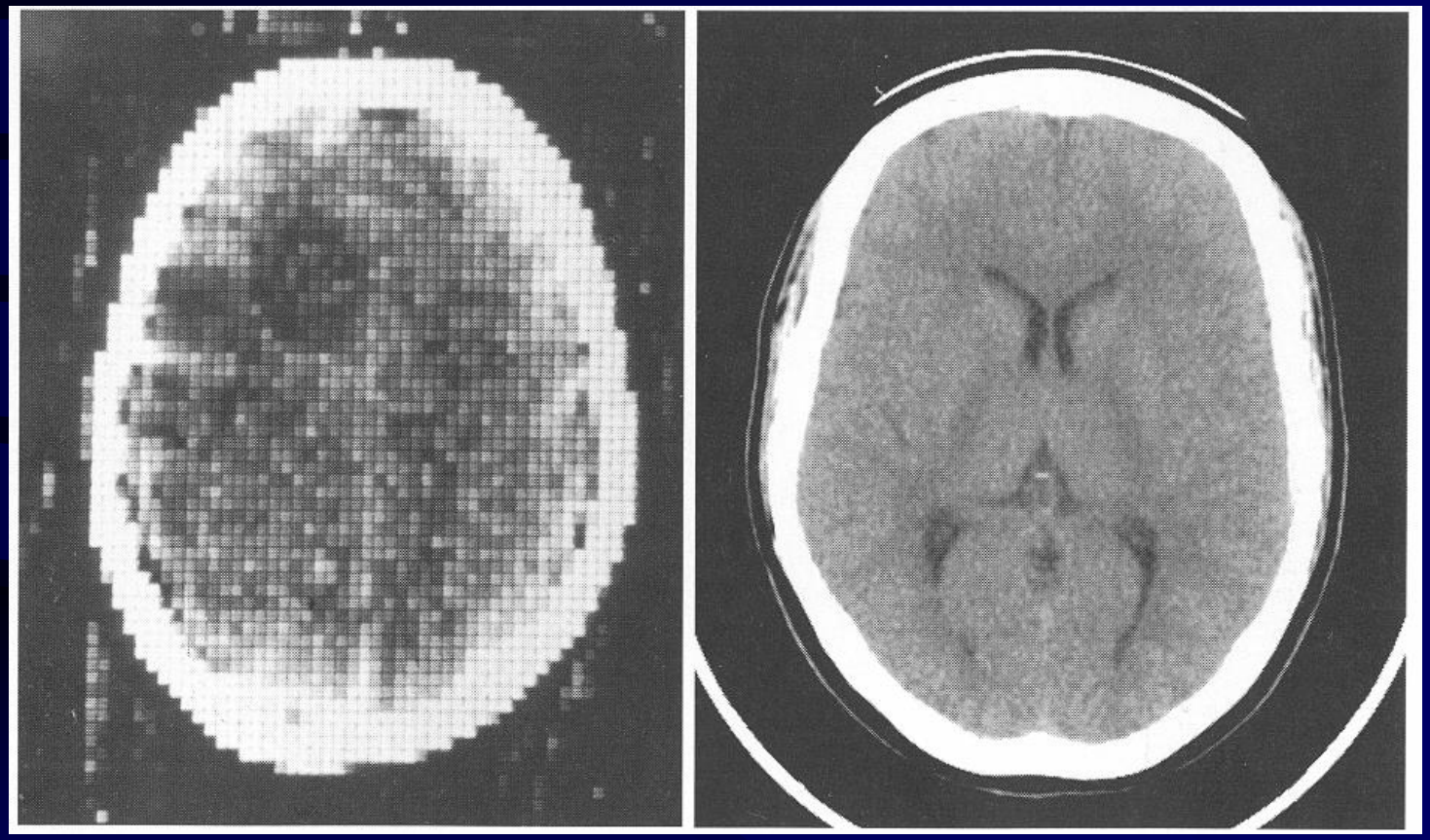


Scanner

CT image

Figure 1.2

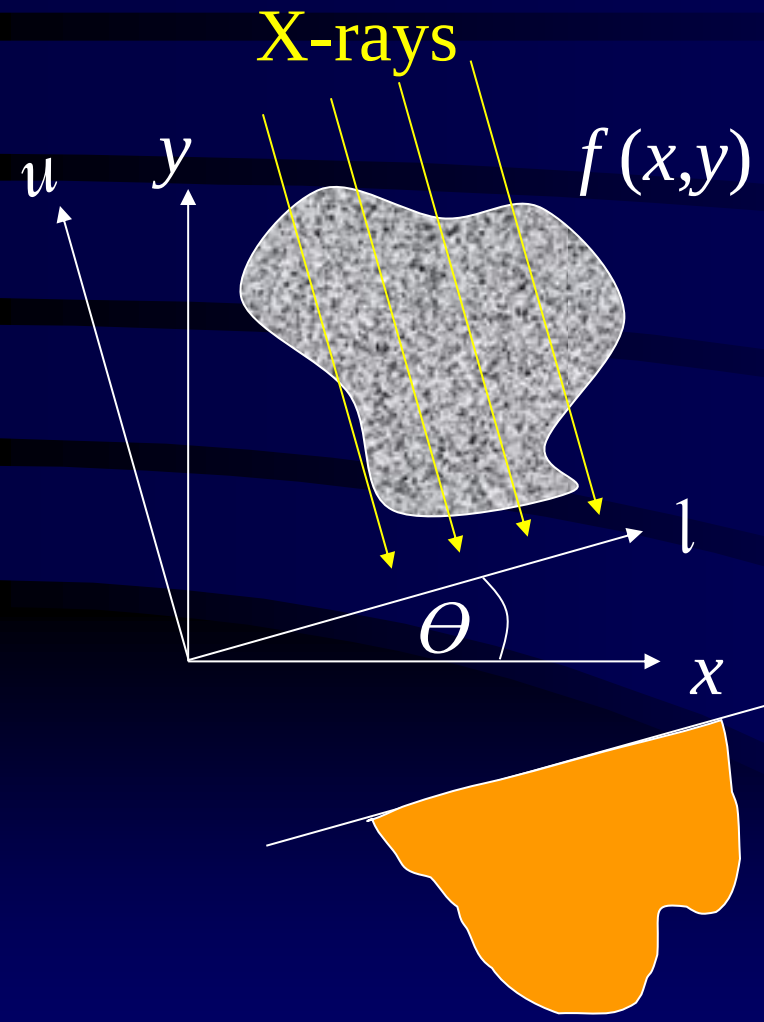
Image Quality: Then and Now



first CT scanners

modern CT scanners

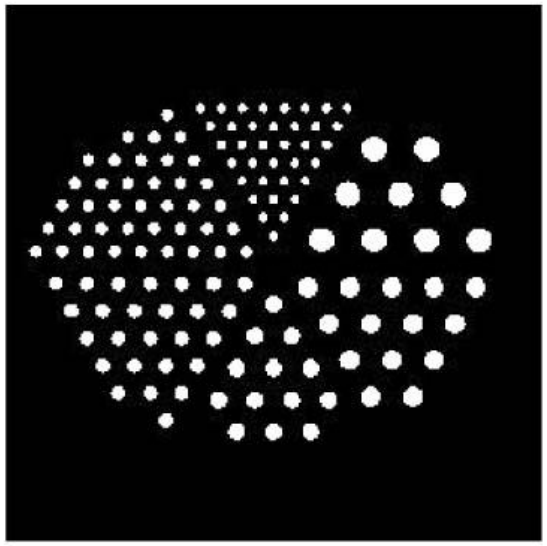
The Mathematics of CT



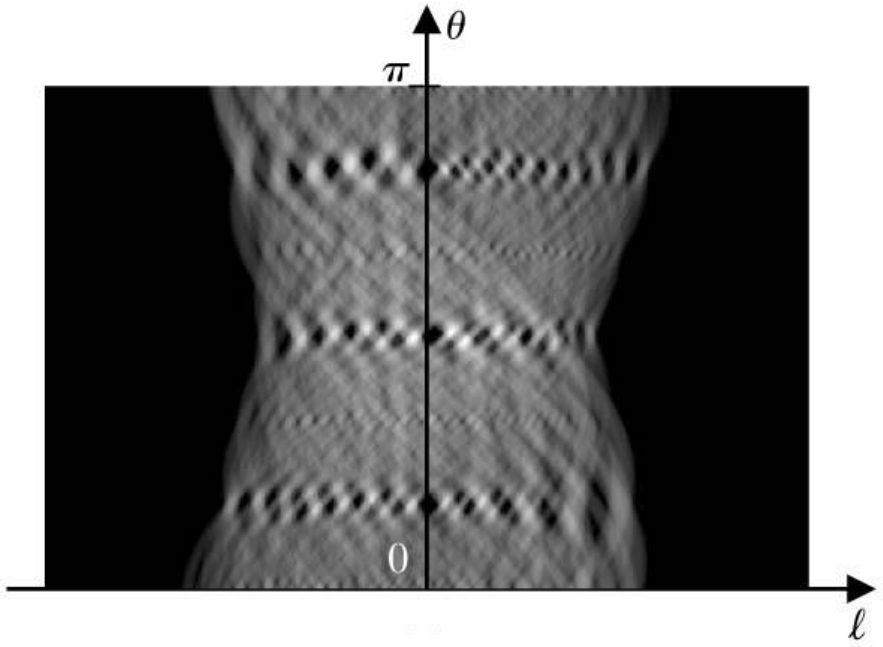
Reconstruct $f(x,y)$ from its projections where a projection in direction u (defined by angle θ) can be obtained by calculating the line integrals along each line parallel to u.

$$g(l,\theta) = \int_{-\infty}^{\infty} f(l\cos\theta - u\sin\theta, l\sin\theta + u\cos\theta)\,du$$

Sinogram



Object



Sinogram of the Object

Sinogram: image of $g(l, \Theta)$ with l and Θ as rectilinear coordinates
Reconstruction: sinogram → image

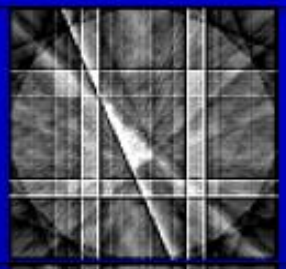
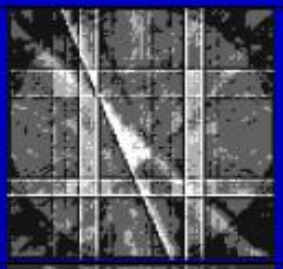
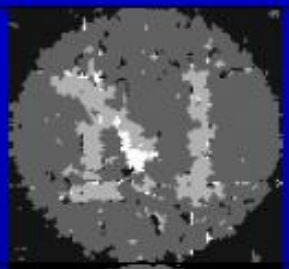
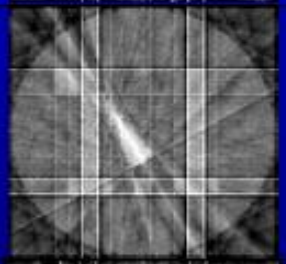
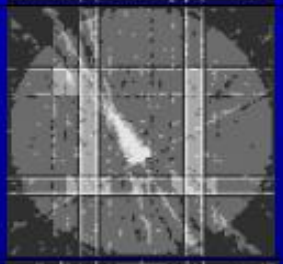
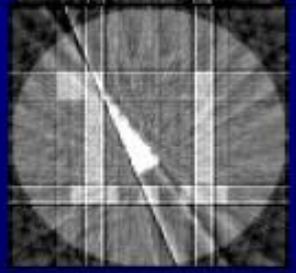
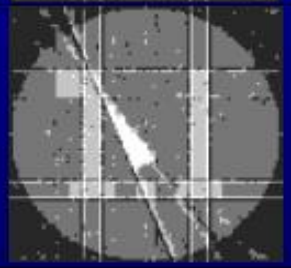
Reconstruction Methods

- Filtered backprojection (FBP) – classical, performs well in case of many projections
- Algebraic methods – can serve as alternative in case of limited projections (in number and/or in space)
- Optimization based methods – can incorporate prior information

Discrete/Binary Tomography

- FBP and ART need several hundreds of projections
  - time consuming
  - expensive
  - may damage the object
  - not possible
- In certain applications the range of the function to be reconstructed is discrete and known $\rightarrow$ DT (only few (2-10) projections are needed)
- Binary Tomography: the range of the function is $\{0,1\}$ (absence or presence of material)

KNOWING THE DISCRETE RANGE

# projs.	Conv. method	Discretized image	DT method
8			
12			
16			

L. Ruskó, A.K., Z. Kiss, L. Rodek, 2003

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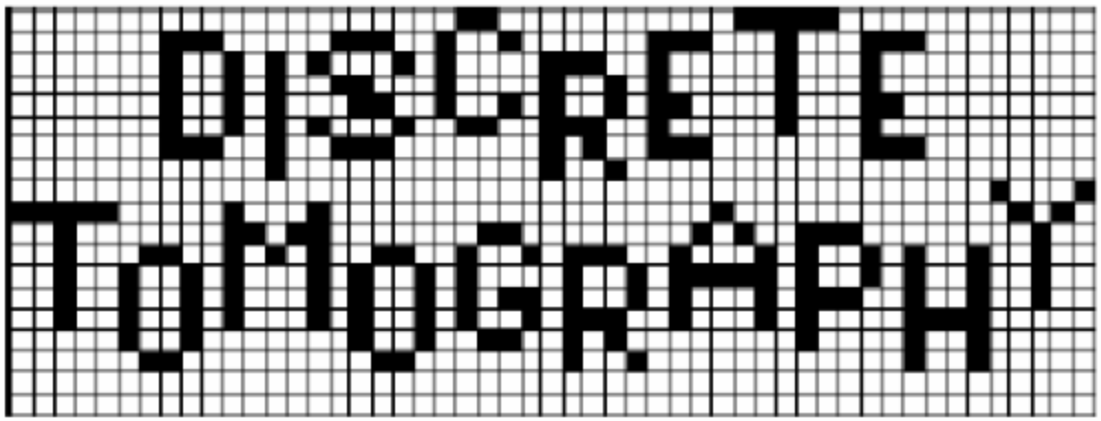
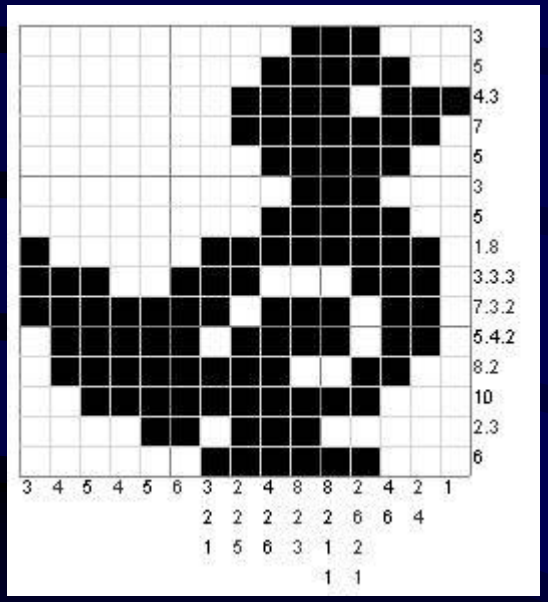
Source: Attila Kuba

Binary Reconstruction from 2 Projections

Binary Reconstruction from 2 Projections



Nonograms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4.3
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5.4.2
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