Medical Image Processing

ULTRASOUND TOMOGRAPHY

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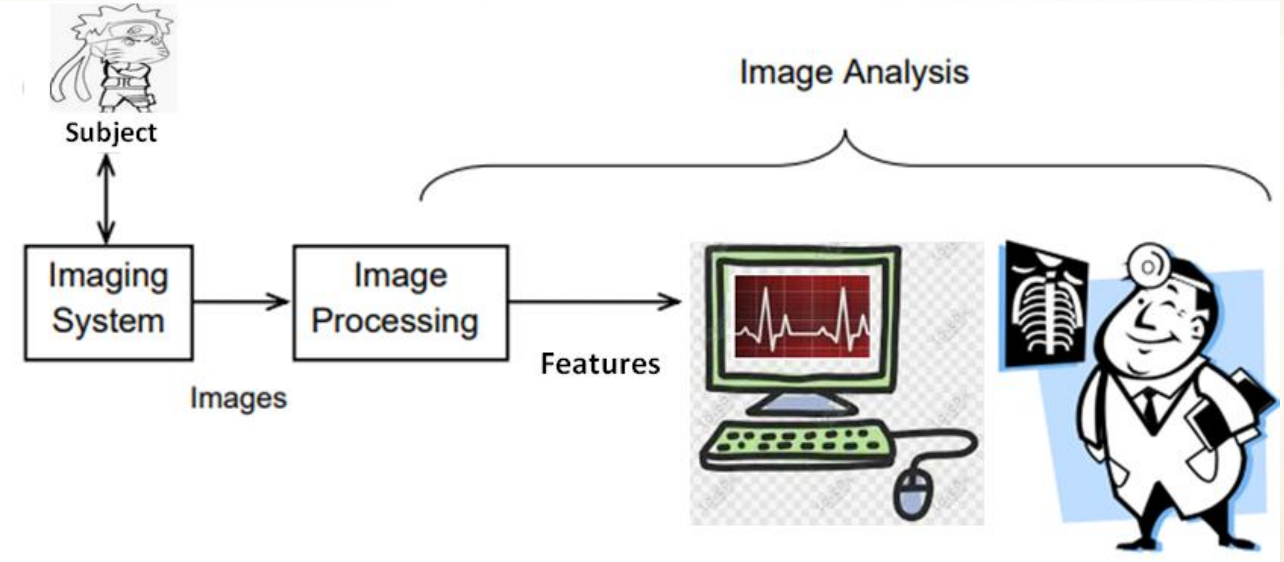
Agustus 2020

Introduction

Medical Image Processing



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Medical Image Processing

What do images represent?

For medical images, pixels may represent parameters such as:

- X-ray attenuation (density)
- Acoustic impedance (distribution)
- Optical reflectivity (or impedance)
- Electrical activity

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Medical Image Processing

Medical images

The values in the image may represent distance, reflectivity, density, temperature, etc.

An image may be composed of:

- 2-D: pixels = picture elements
- 3-D: voxels = volume elements
- 4-D and higher: hyper voxels = hyper volume elements

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Medical Image Processing

Purposes of image processing

- Preprocess image to reduce noise and blur (filtering)
- Identify structures within the image (segmentation)
- Extract “useful” information from the image (quantification, classification)
- Prepare the image for visualization (enhancement, reconstruction)

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Ultrasound tomography

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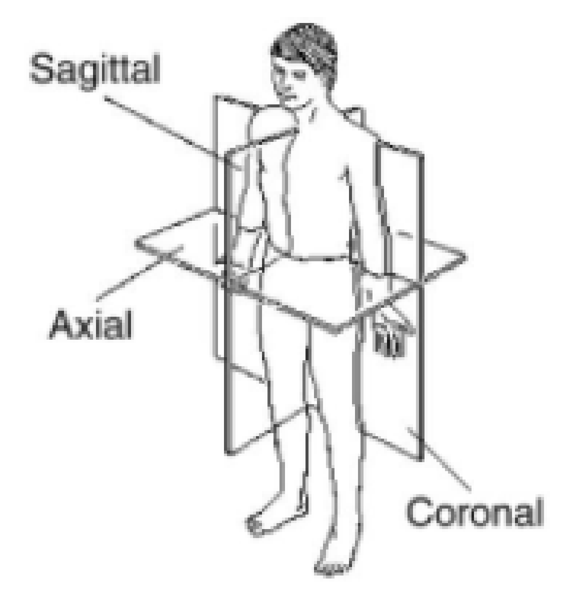
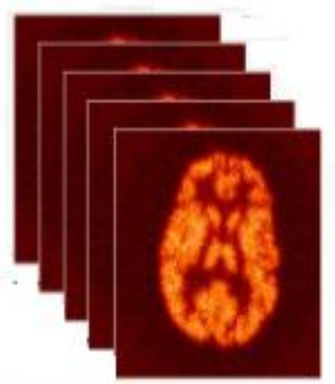
Tomography

tomos **= "slice, section"**
graphō **= "to write, to describe"**

Imaging by sections or sectioning through the use of any kind of penetrating wave





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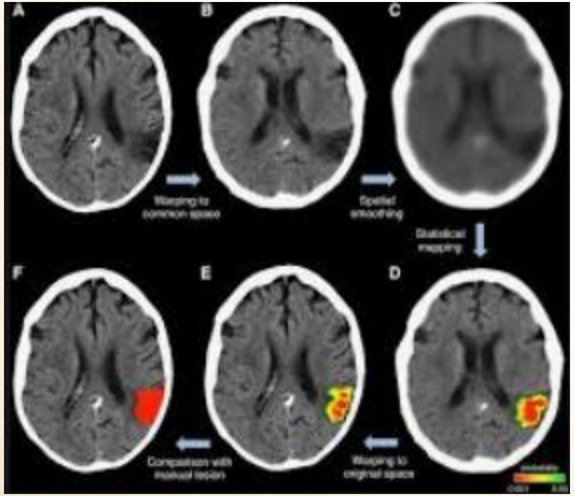
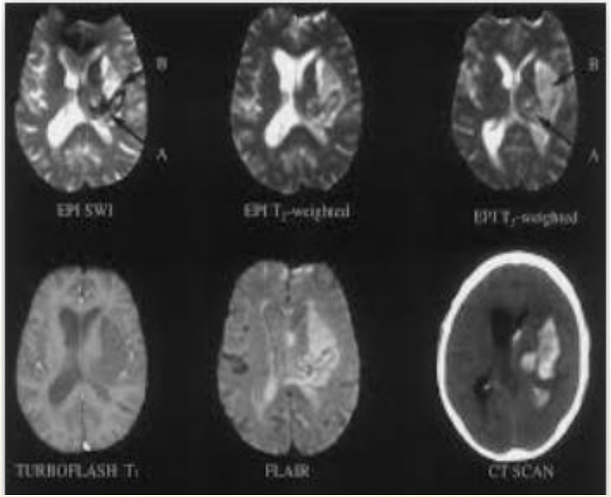
Tomography images





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Ultrasound tomography

Ultrasound

Ultrasound uses sound waves to generate a medical image of human anatomy.
The frequency of ultrasound is higher than the sound wave frequencies that can be detected by human hearing.
Sound waves can only travel through a medium, so a water-based gel needs to be applied to the skin, which allows the ultrasound to be transmitted from the transducer or probe into the body.

Ultrasound advantages

- Ultrasound scanning is non-invasive.
- Ultrasound is widely available, easy-to-use and less expensive than other imaging methods.
- Ultrasound imaging uses non ionizing radiation.
- Ultrasound scanning gives a clearer image of soft tissues than x-ray images.
- Ultrasound causes no health problems and may be repeated as often as is necessary.
- There are no hazards for the patient and operator.

Disadvantages :

- Resolution of images is often limited.
- Bone absorbs ultrasound so that brain images are hard to get.
- Attenuation can reduce the resolution of the image.
- Sonography performs very poorly when there is a gas between the transducer and the organ

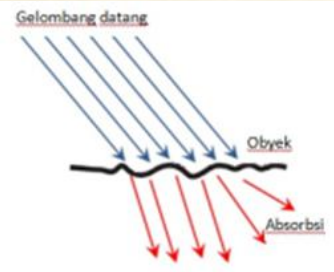
Ultrasound parameters

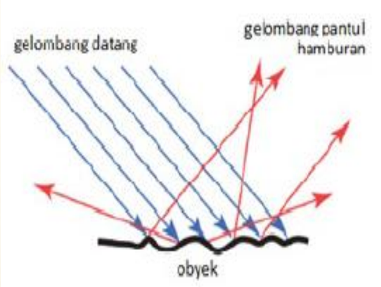
Medium	Speed of sound (ms^{-1})	Characteristic impedance (kgm^2s^{-1})	Half depth at 3 MHz (cm)
Blood	1585	1.68×10^6	1.2
Liver	1580	1.66×10^6	1.7
Muscle skeletal	1575	1.64×10^6	1
Fat	1430	1.31×10^6	2.5-0.7
Bone (skull)	2800	5.60×10^6	0.04
Water (20°C, 1 atm)	1482	1.48×10^6	150
Air (20°C, 10% humidity)	331	392	0.2

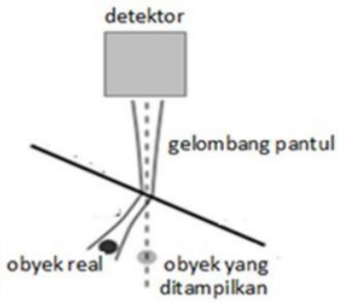
$$v = \sqrt{\frac{C}{\rho}}$$

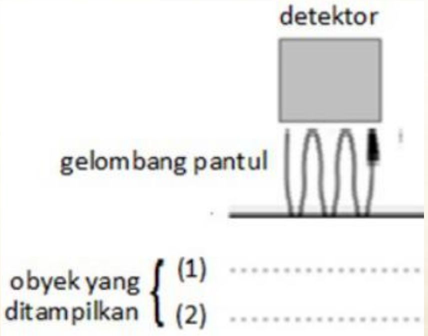
$$s = \frac{t \times c}{2}$$

C is the bulk modulus and ρ is the density o f the material









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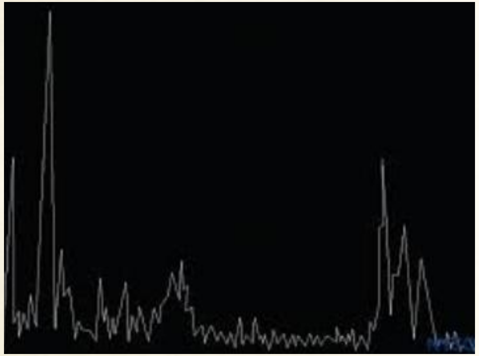
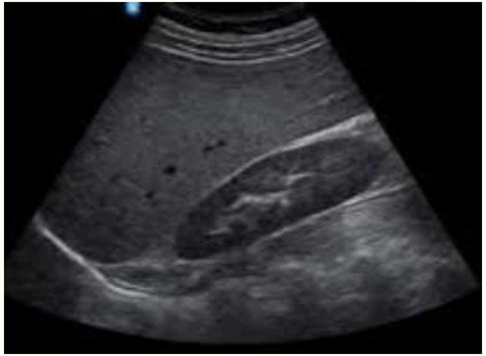
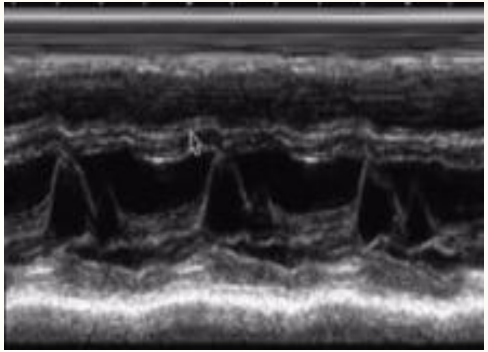
Ultrasound image



A – Mode (Amplitude)
used to judge the depth of an organ and assess an organ's dimensions



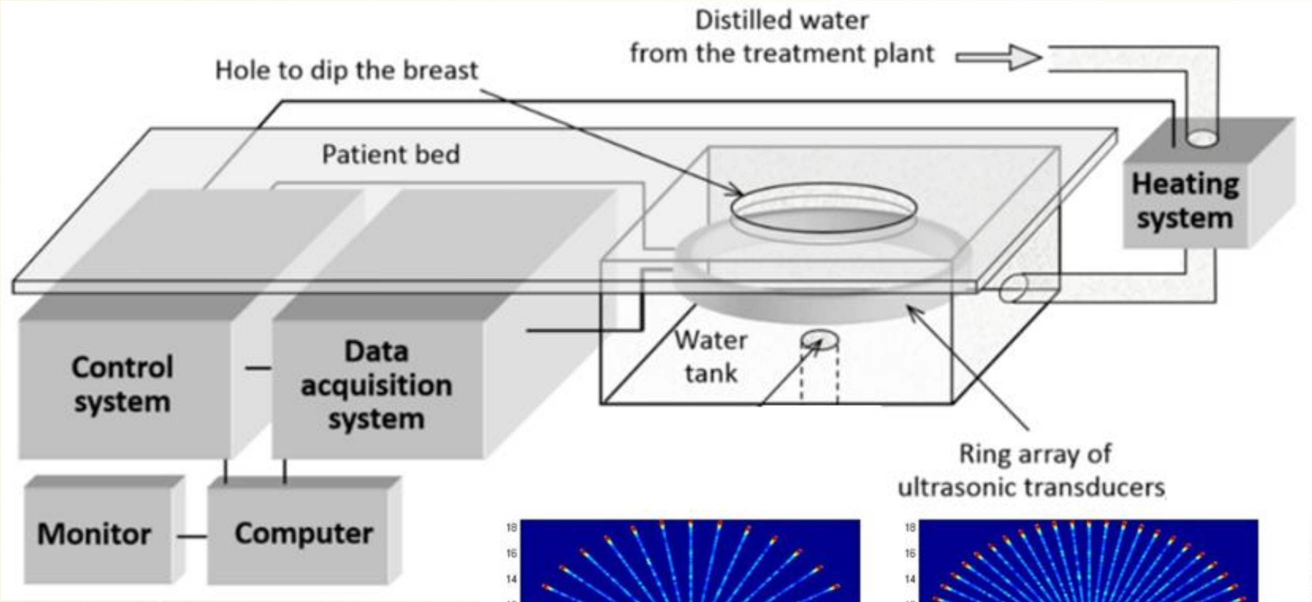
B – Mode (Brightness)
display of a 2D-map of intensity and most common form of US imaging

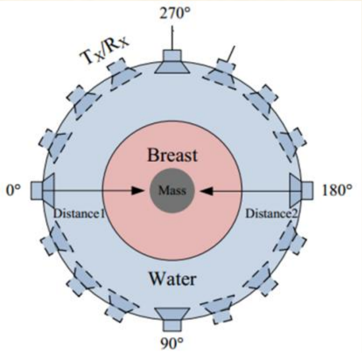


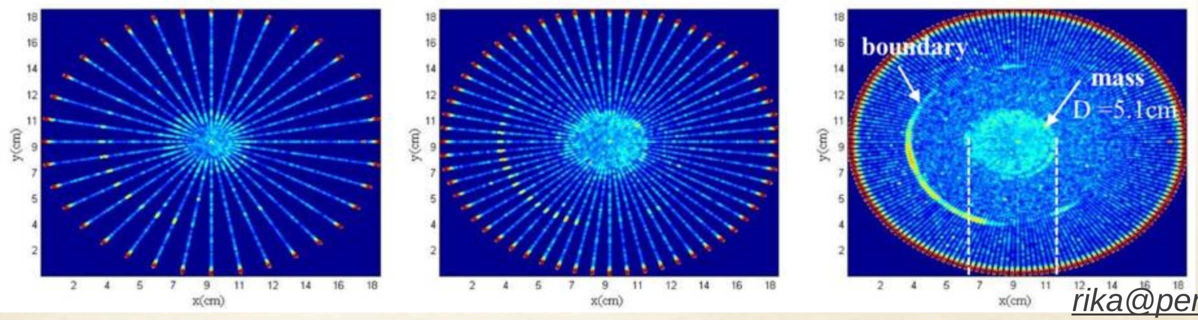
M-mode (Motion)
used for analyzing moving body parts, commonly in cardiac and fetal cardiac imaging

Ultrasound tomography

Breast cancer detection – non freehand







The algorithm only needs to detect the half depth of the detection target

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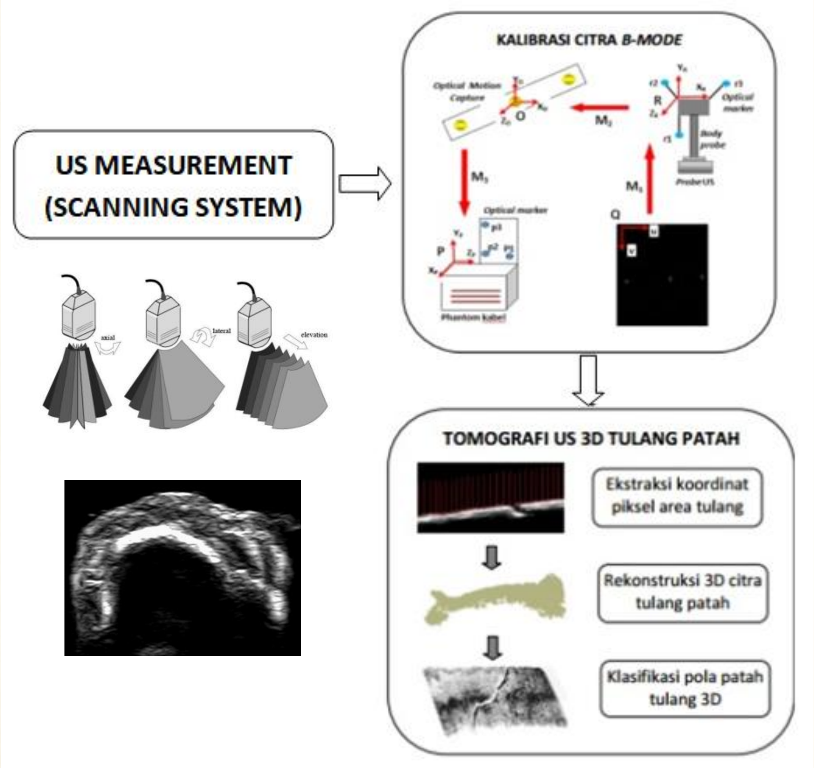
Ultrasound tomography

Long-bone fracture detection -freehand



Freehand : free orientation and position

Calibration using tracker camera and optical marker

Calibration

$$\begin{bmatrix} x \\ y \\ z \\ 1 \end{bmatrix} = M_3 \cdot M_2 \cdot M_1 \cdot S_{xy} \begin{bmatrix} u \\ v \\ 0 \\ 1 \end{bmatrix}$$

$$M_n = \begin{bmatrix} R^R{}_{(3x3)} & t^R{}_{(3x1)} \\ 0_{1x3} & 1 \end{bmatrix}$$

$$R^R = \begin{bmatrix} v_{xR} & v_{yR} & v_{zR} \end{bmatrix}$$

$$t^R = (x_2, y_2, z_2)^T$$

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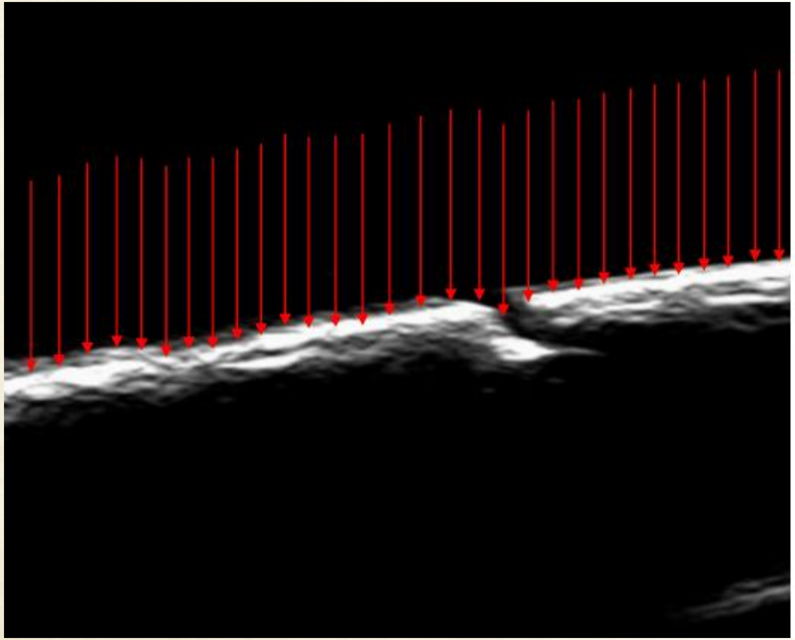
Ultrasound tomography

Pixels coordinate extraction

column scanning → edge pixel (u, v)



$$L_i = \begin{bmatrix} u_{i1} & u_{i2} & \cdots & u_{iNi} \\ v_{i1} & v_{i2} & \cdots & v_{iNi} \\ 0 & 0 & \cdots & 0 \\ 1 & 1 & \cdots & 1 \end{bmatrix}$$

i = citra B-mode ke - *i*
(u,v) = koordinat piksel dalam bidang 2D
Ni = jumlah *edge pixe*l dalam citra ke *i*
N = jumlah citra *B-mode* dalam pemindaian sa tu obyek tulang

$$l = (l_1, l_2, l_3, \cdots, l_N)$$

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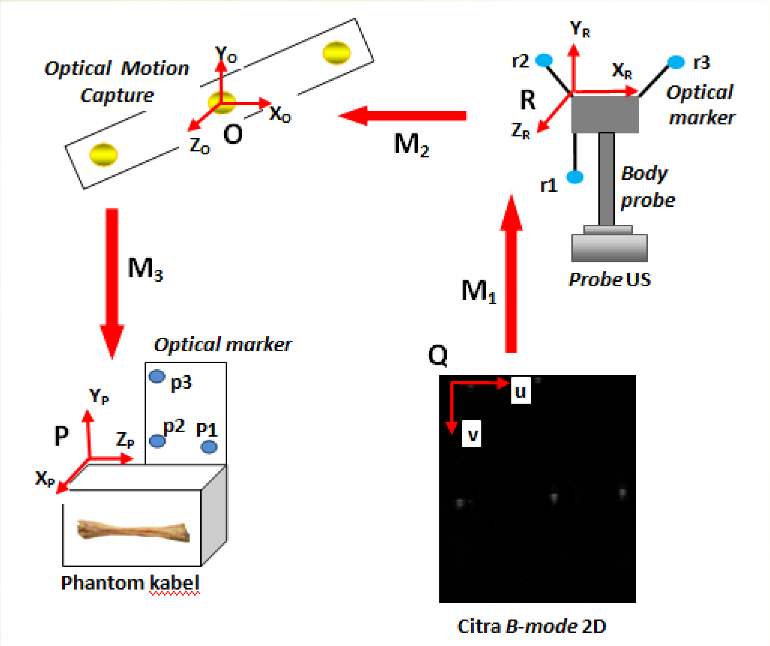

$$Q = (Q_1, Q_2, Q_3, \cdots, Q_N)$$

$$\boldsymbol{Q_i} = \boldsymbol{M_{3i}} \cdot \boldsymbol{M_{2i}} \cdot \boldsymbol{M_1} \cdot \boldsymbol{S_{xy}} \cdot \boldsymbol{L_i}$$

$$\boldsymbol{L_i} = \begin{bmatrix} u_{i1} & u_{i2} & \cdots & u_{iNi} \\ v_{i1} & v_{i2} & \cdots & v_{iNi} \\ 0 & 0 & \cdots & 0 \\ 1 & 1 & \cdots & 1 \end{bmatrix}$$

$$\boldsymbol{S_{xy}} = \begin{bmatrix} 0.0804 & 0 & 0 & 0 \\ 0 & 0.0804 & 0 & 0 \\ 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix}$$

$$\boldsymbol{A_i} = \begin{bmatrix} a_{i11} & a_{i12} & a_{i13} & a_{i14} \\ a_{i21} & a_{i22} & a_{i23} & a_{i24} \\ a_{i31} & a_{i32} & a_{i33} & a_{i34} \\ 0 & 0 & 0 & 1 \end{bmatrix}$$

$$\boldsymbol{M_1} = \begin{bmatrix} m_{11} & m_{12} & m_{13} & m_{14} \\ m_{21} & m_{22} & m_{23} & m_{24} \\ m_{31} & m_{32} & m_{33} & m_{34} \\ 0 & 0 & 0 & 1 \end{bmatrix}$$

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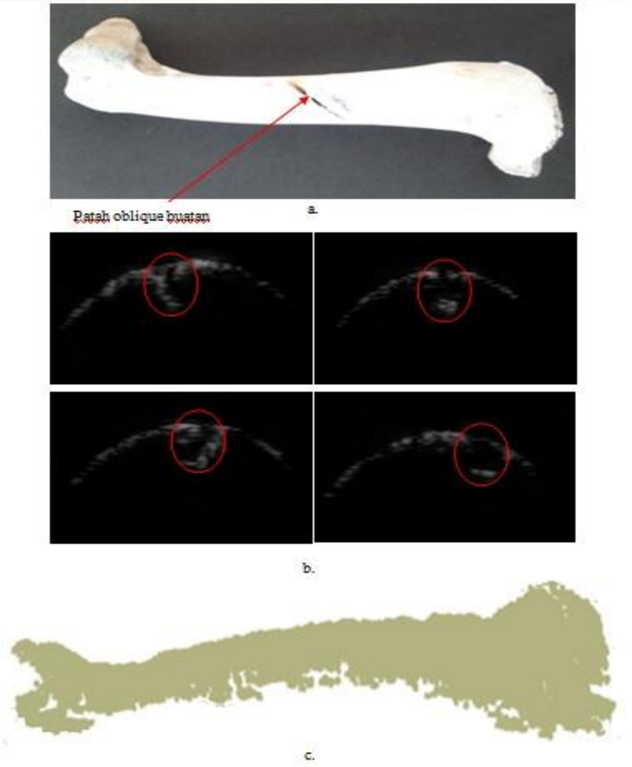
Ultrasound tomography



Tulang kambing : jarak antar slice min 0.3084

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Sekian ….. terima kasih…

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