Medical Ultrasound Lab
医学超声实验室

Ultrasound computer tomography based on compressed sampling

1/27/2015

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- Ultrasound computer tomography (UCT)

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Motivations of UCT

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Breast cancer

China: female, 15% of all cancer cases, but only 6.2% of cancer deaths

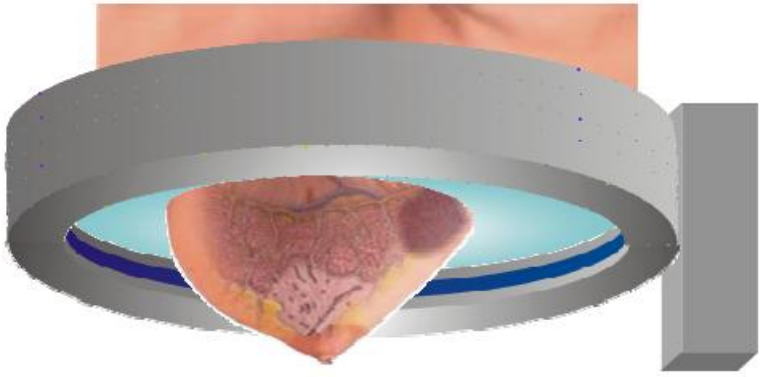
CT, MRI, Ultrasound

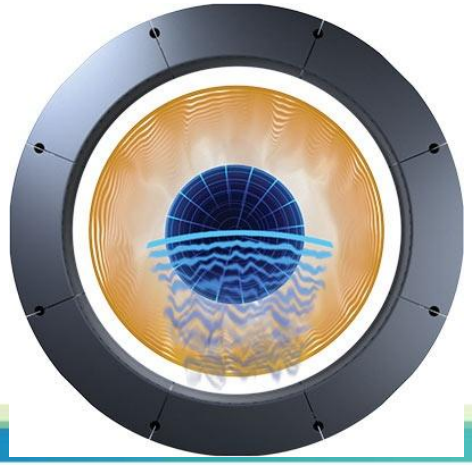
UCT systems

- SoftVue (Karmanos Cancer Institute in Detroit, MI, USA. KCI)

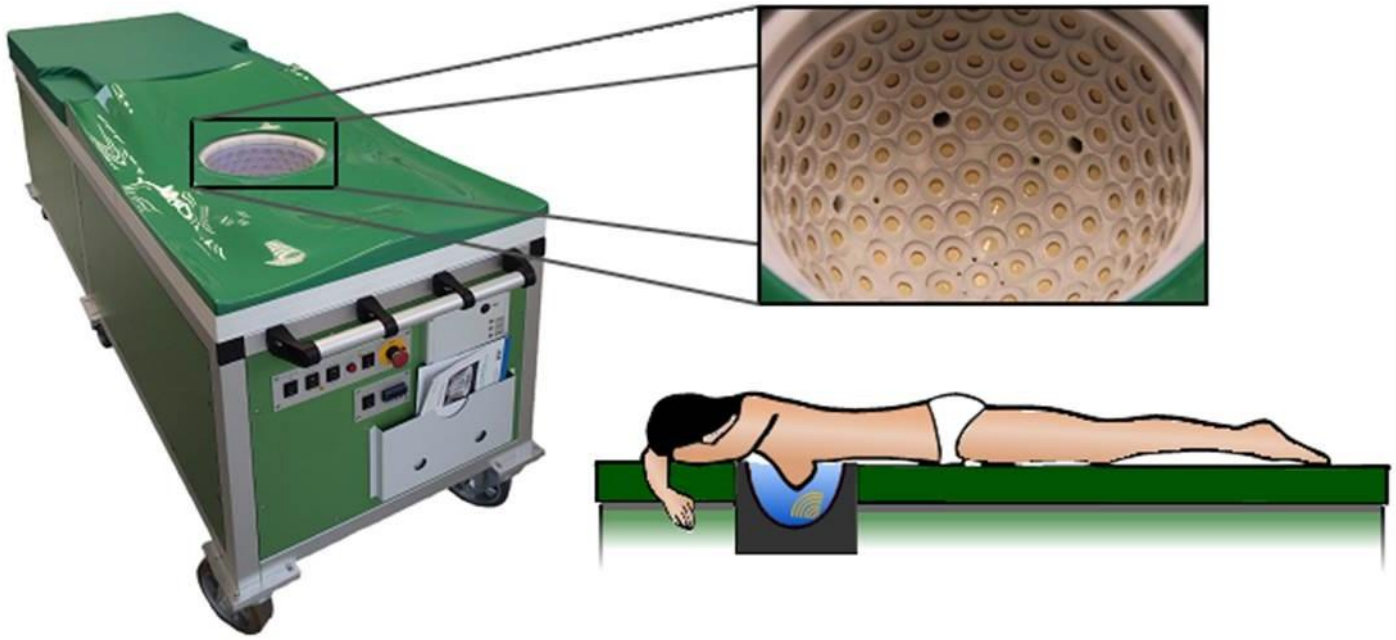
- 3D UCT system (Karlsruhe Institute of Technology, Germany. KIT)

SoftVue





3D UCT system of KIT



Reconstructions

- Reflection reconstruction
- Sound-speed reconstruction
- Attenuation reconstruction

Problems

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- Complexity
- A large amount of data
- New reconstruction methods

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Reference

[1] Torsten Hopp et al. Breast Imaging with 3D Ultrasound Computer Tomography: Results of a First In-vivo Study in Comparison to MRI Images. IWDM 2014, LNCS 8539, pp. 72–79, 2014.

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[3] N.V. Ruiter et al. First Results of a Clinical Study with 3D Ultrasound Computer Tomography. 2013 Joint UFFC, EFTF and PFM Symposium

[4] Youzuo Lin and Lianjie Huang. Ultrasound waveform tomography with a modified total-variation regularization scheme. Medical Imaging 2013: Ultrasonic Imaging, Tomography, and Therapy, edited by Johan G. Bosch, Marvin M. Doyley, Proc. of SPIE Vol. 8675, 86751F.

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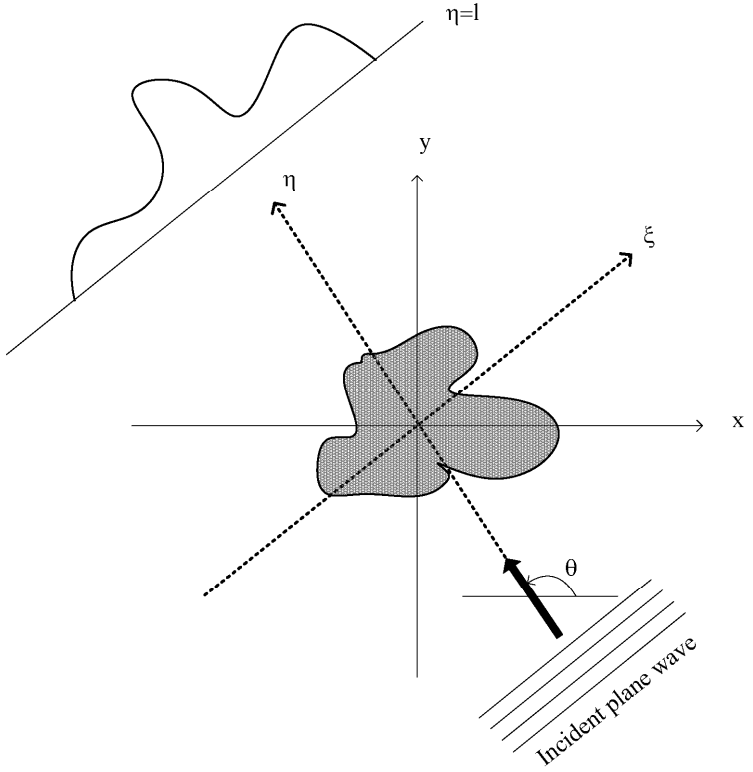
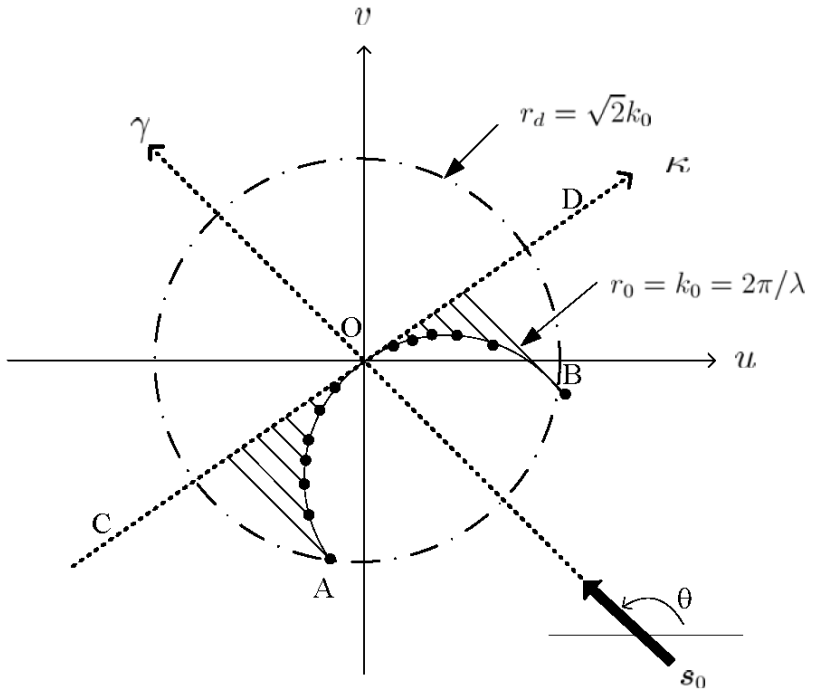
http://www.delphinusmt.com/our-technology/softvue-system (KCI)
http://www.ipe.fzk.de/~ruiter/Papers.htm (KIT)

UDT based on CS





Sparse-View Ultrasound Diffraction Tomography Using Compressed Sensing with Nonuniform FFT. Shaoyan Hua, et al, Computational and Mathematical Methods in Medicine, 2014.

CS theory

$$y = \Phi x = \Phi \Psi s = \Theta s$$

◆Measurement matrix: $\Phi = \begin{bmatrix} 0 & 1 & 0 & 0 & 0 & \cdots & 0 \\ 0 & 0 & 0 & 1 & 0 & \cdots & 0 \\ \vdots & \vdots & \vdots & \vdots & \vdots & \cdots & \vdots \\ 1 & 0 & 0 & 0 & 0 & \cdots & 0 \end{bmatrix}$

◆Sparse basis： Fourier、Wavelet

◆Reconstruction： $\min \| s \|_1 \quad s.t. \quad y = \Theta s$

$$\left(\nabla^2 + k_0^2\right) u(\mathbf{r}) = -k_0^2 f(\mathbf{r}) u(\mathbf{r}),$$

$$F = \Phi(f),$$

$$\min_{s} G(s) = \alpha \mathrm{TV}(\Psi \mathbf{s}) + \beta \|\mathbf{s}\|_1 + \|F - \Phi\Psi\mathbf{s}\|_2^2,$$

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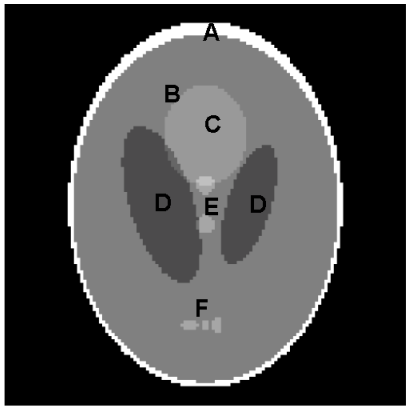
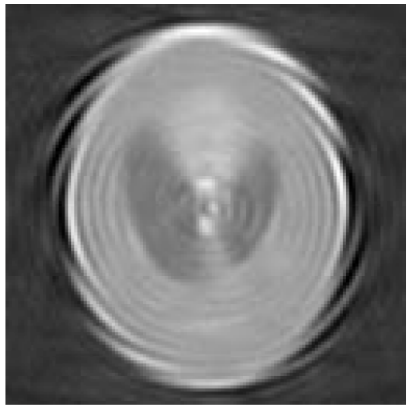
16views,128elements, pitch=wavelength

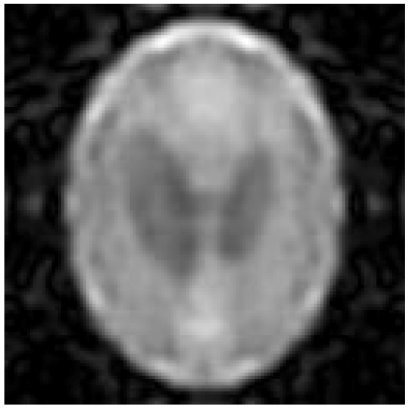


(a)



(b)

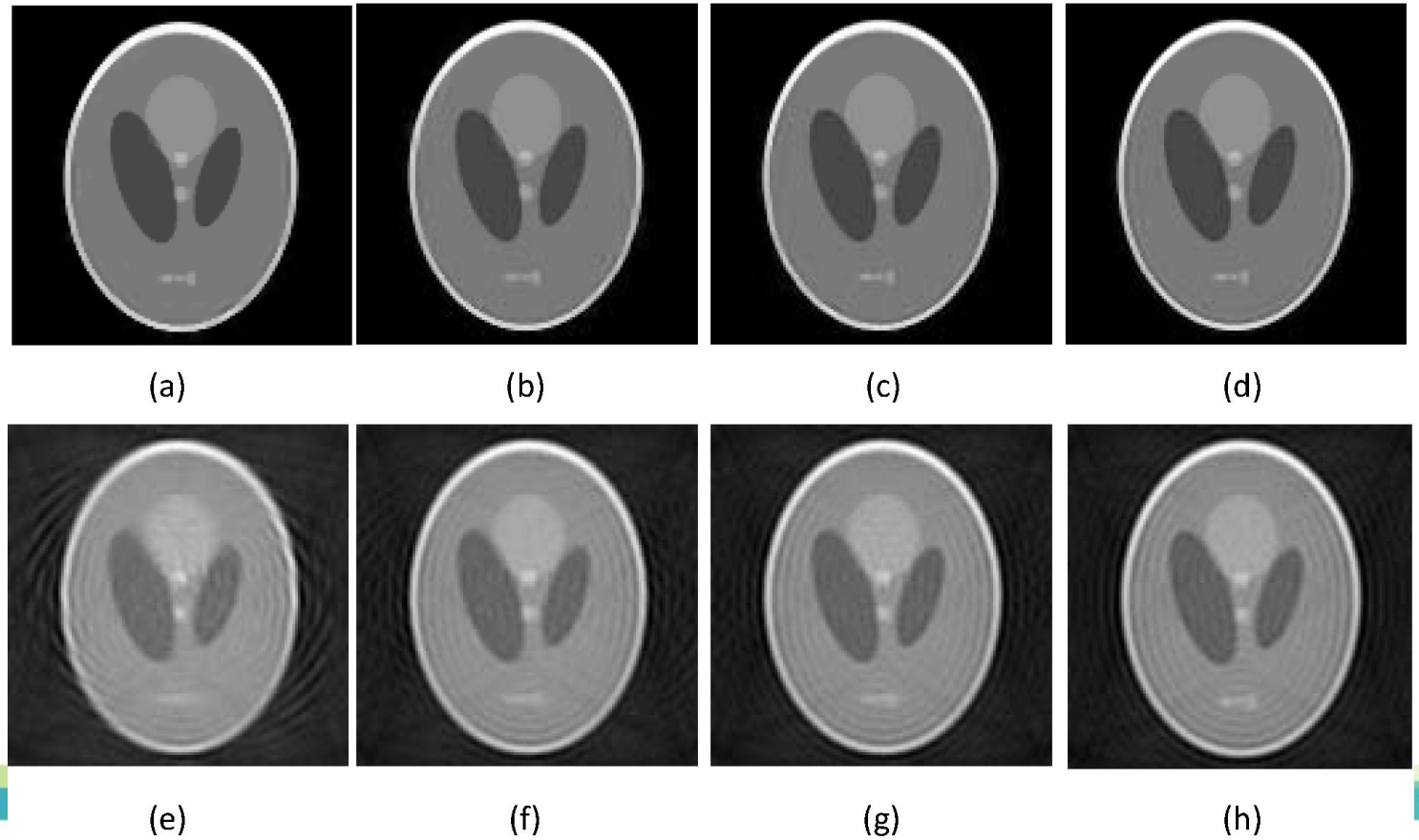
(a) Original image.
(b) Interpolation method.
(c) Broadband signal.
(d) CS.



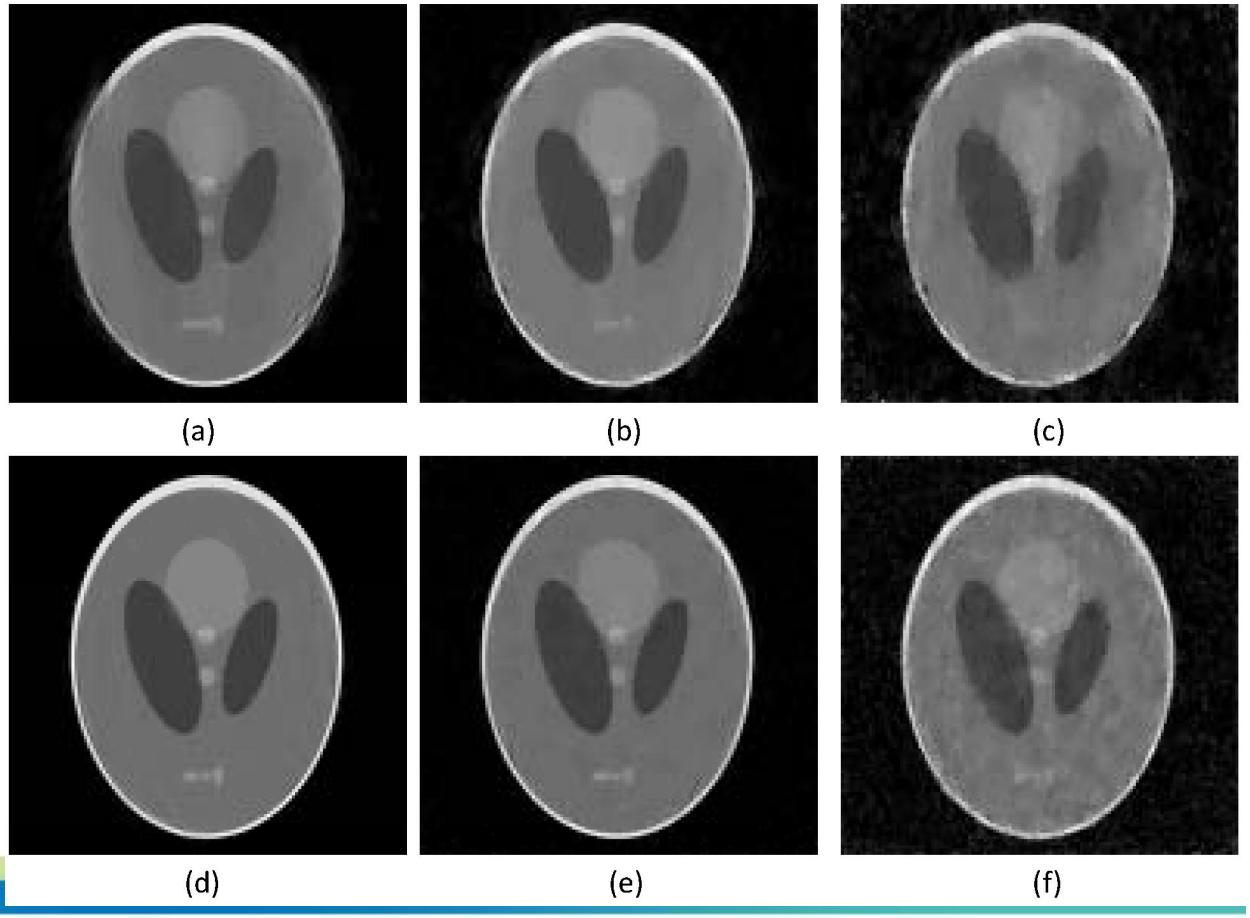
(c)

(d)

CS and interpolation method with different views：32,48,64,96



The robustness to noise of the proposed method.



(a) 16 views, noise-free;
(b) 16 views, SNR =20dB ;
(c) 16 views, SNR =10dB;
(d) 32views,noise-free;
(e) 32views,SNR=20dB;
(f) 32views,SNR =10dB.

Reference

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