

# Deep learning in ultrasound image analysis

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<https://qdata.github.io/deep2Read>

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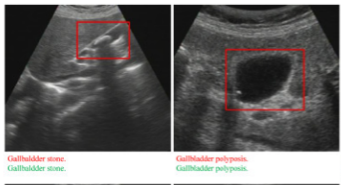
**Medical imaging modalities:** MRI, CT, X-ray, US

**Properties of the US:** safety, low cost, noninvasive nature, real-time display, operator comfort, and operator experience

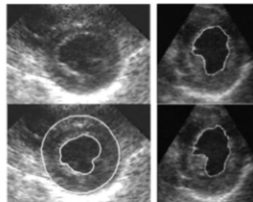
**Challenges of the US:** low imaging quality caused by noise and artifacts, high dependence on abundant operator or diagnostician experience, and high inter- and intra-observer variability across different institutes.

# Applications of deep learning in US analysis:

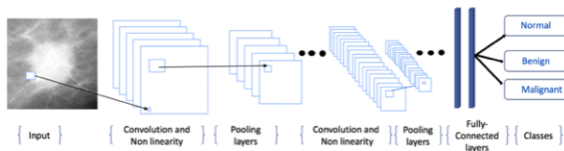
Classification, segmentation, detection, registration, biometric measurements, and quality assessment.



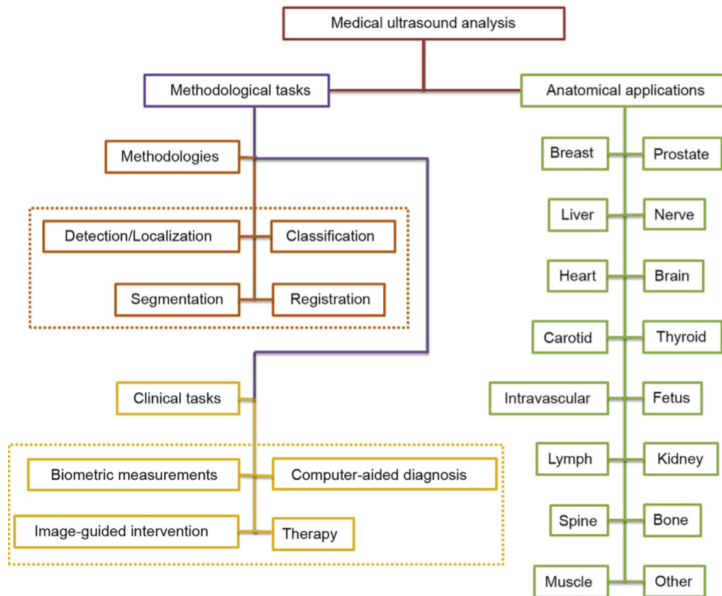
Detection



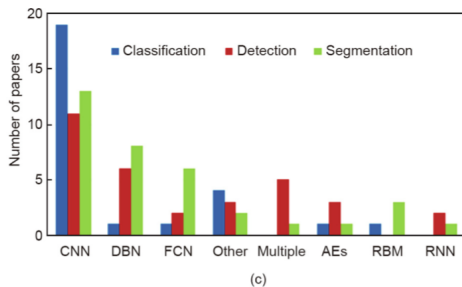
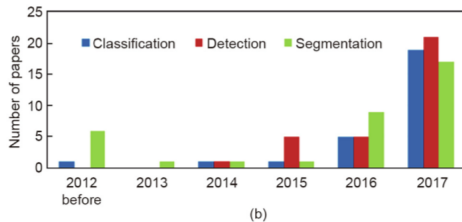
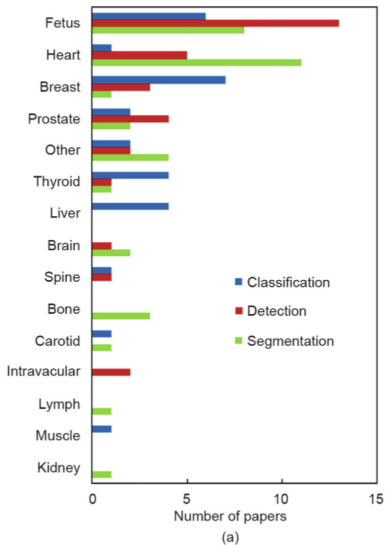
Segmentation



Classification



**Fig. 1.** Illustration of medical US analysis.



## Classification:

### **Tumors or lesions** Several solutions:

- utilize various handcrafted features extracted from US images in combination with a multi-way linear classifier  
**limitation:** Susceptible to image distortion, such as deformation due to the internal or external environments, or to conditions in the imaging process.
- utilize unsupervised learning to learn image representation, and use the learned feature as input to supervised models.
- purely supervised model.

### **liver cancer**

- Linear discriminant analysis (LDA), kNN, SVM, and back propagation net (BPN).
- Deep canonical correlation analysis (DCCA)—a variant of canonical correlation analysis (CCA)—combined with a multiple kernel learning (MKL) classifier

## Nodules

two CNNs were trained on a large thyroid nodule US dataset separately, and then the two learned feature maps were fused as input into a softmax layer in order to diagnose thyroid nodules.

## Segmentation

- Energy model: Partial differential equation based. Propose an energy function and optimize it based on Euler-Lagrange differential equation. Active contour, normalized cut
- Deep learning models: bottom-up and top-down models, FCN segmentation network.

Image denoising:

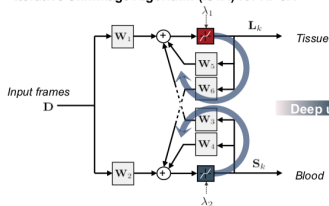
$D = L + S$ , where  $L$  is low rank and  $S$  is sparse.

Solutions

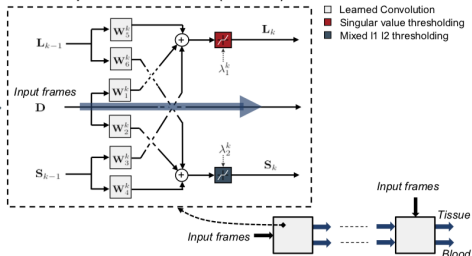
- ISTA, FISTA
- LISTA, LFISTA, Convolutional robust PCA



### a Iterative Shrinkage Algorithm (ISTA) for RPCA

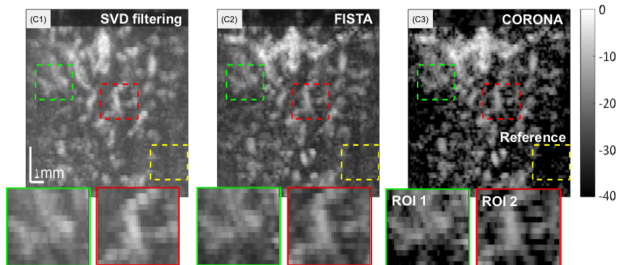


### b Deep Convolutional RPCA (CORONA)



### c In-vivo experiments

#### C In-vivo experiments



Super-resolution Reconstruction  $Y = AX + w$  where  $y$  is the vectorized image frame of the ultrasound sequence,  $A$  is the measurement matrix where each column of  $A$  is the point-spread-function shifted by a single pixel on the high-resolution grid, and  $w$  is a noise vector.

