Left Ventricle Segmentation in Cardiac Ultrasound Using Hough-Forests With Implicit Shape and Appearance Priors
Fausto Milletari¹, Mehmet Yigitsoy¹, Nassir Navab¹,³, and Seyed-Ahmad Ahmadi²

Motivation
- US has advantageous properties for cardiac imaging
  - Radiation free
  - Real-Time
- Cardiac functionality assessed via Left Ventricle volume estimation
- Manual segmentation of Left Ventricle is time-consuming

Related Work
- Pedestrian segmentation using Hough forests [1]
- Automatic LV segmentation based on deep learning [2]

Our contribution
- Fully automatic segmentation method based on Hough forest
  - Incorporates shape and appearance knowledge
  - Predicts position of the LV center
  - Predicts probabilistic segmentation

Training Stage
- Each data-point from training images
  - Corresponds to a patch
  - Is described by N-dimensional intensity based feature vector
  - Carries spatial displacement between itself and LV center
  - Is associated with segmentation patch from ground truth
  - Is associated with appearances occurring in correspondence of segmentation
  - Foreground = boundaries in US image

Testing Stage
- Object center localization
  - Classification of each data-point
  - Data-points that are classified as foreground vote for LV center
  - Votes are weighted by confidence and accumulated into volume
  - Position of maximum accumulation is LV center
- Contour Estimation
  - Each vote falling near LV center re-projected to position x of the data-point that cast it
  - Obtain segmentation patch S_p corresponding to the vote from the code base
  - Recover intensity patch I_p corresponding to S_p
  - Apply segmentation S_p at location of data-point after weighting with truncated NCC between I_p and the intensities around x
  - Accumulate segmentation patches and normalize to obtain final segmentation

Results
- 15 end-diastolic test images:
  - Mean Absolute Distance: 2.37 mm
  - Mean Hausdorff distance: 9.52 mm
  - Mean mod. Dice coefficient: 0.123
- 15 end-systolic test images:
  - Mean Absolute Distance: 2.93 mm
  - Mean Hausdorff distance: 8.64 mm
  - Mean mod. Dice coefficient: 0.166

Conclusions
- Bigger segmentation patches generate smoother contours
  - More shape than appearance regularization
- Outliers during classification do not degrade performance
  - Unless their votes accumulate in strong peaks
  - Prefer features that are directionally discriminative instead of class discriminative

References