Digital Signal Processing Group

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# On the use of motion-based frame rejection in temporal averaging denoising for segmentation of echocardiographic image sequences

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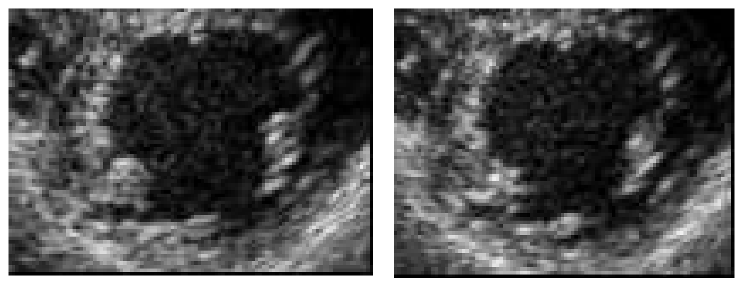
- Semi-automatic segmentation of the left ventricular wall in short-axis echocardiographic images
- Pre-processing: temporal averaging for image denoising.
  - Motion estimation is used to detect and reject frames that do not correlate well with the set of images being averaged.
  - Segmentation: histogram-based thresholding, region labeling, and neighborhood operations
- Main contributions are :
  - to reduce the algorithm's computational load without significantly reducing the segmentation quality with two approaches.
  - First: motion detection is performed by taking the pixel-by-pixel difference between frames - five frames with stronger motion are removed from the image set
  - Second: temporal averaging without frame rejection using smaller window size

## Motion quantification using image subtraction



temporally-adjacent frames

pixel-by-pixel difference between the two frames

## Smaller window size

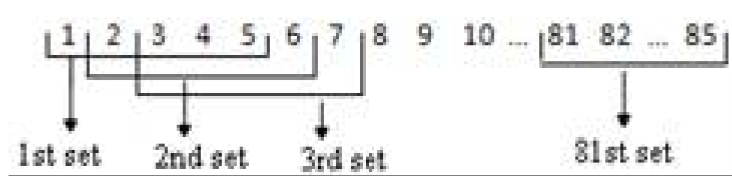


Table 1 – Quantitative comparison between the three proposed approaches and other methods from the literature.

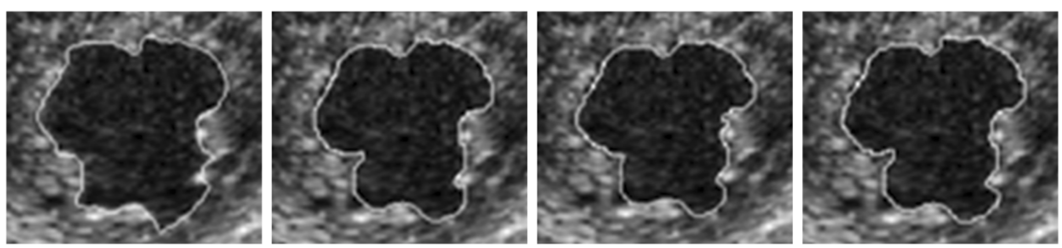
| | *image quality - # of images* | *CCC*[a] | *PE (%)*[b] | *ES (%)*[b] | *EPE*[c] | *Proc. Time*[d] |
|---|---|---|---|---|---|---|
| Optic flow [10] | good - 10 | 0.95 | 3.52 ±1.24 | 9.47 ±2.02 | 1.04<EPE<1.21 | 20 min |
| | medium - 10 | 0.90 | 11.96 ±3.38 | 16.49 ±2.15 | 2.01<EPE<2.61 | |
| | low - 5 | 0.68 | 21.98 ±7.04 | 35.50 ±7.27 | 5.04<EPE<5.95 | |
| Pixel-by-pixel subtraction | good - 10 | 0.94 | 6.15 ±2.56 | 11.38 ±3.05 | 1.14<EPE<1.41 | 10 min |
| | medium - 10 | 0.90 | 12.71 ±4.36 | 13.32 ±3.99 | 2.61<EPE<2.91 | |
| | low - 5 | 0.67 | 23.65 ±8.36 | 36.32 ±8.32 | 5.91<EPE<6.95 | |
| Small sliding window | good - 10 | 0.93 | 6.40 ±2.60 | 11.98 ±3.19 | 1.25<EPE<1.52 | 6 min |
| | medium - 10 | 0.88 | 14.36 ±3.95 | 14.01 ±4.02 | 2.97<EPE<3.99 | |
| | low - 5 | 0.63 | 24.99 ±8.55 | 36.02 ±9.08 | 6.08<EPE<7.11 | |
| de Andrade *et al.* [7] | good - 20 | 0.98 | 2.49 ± 2.46 | 9,62 ± 7,9 | - | - |
| Klingler *et al.* [3] | - | 0.93 | - | - | - | - |
| Coppini *et al.* [12] | 500 | - | - | - | 0.53<EPE<0.77 | - |

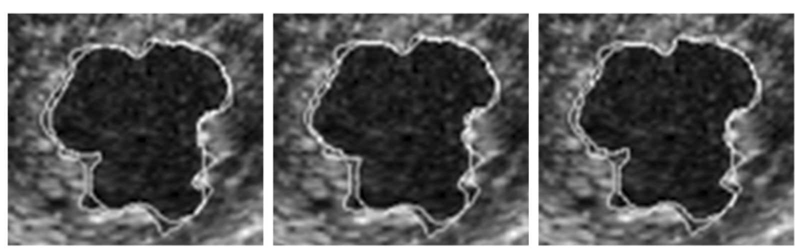
[a] mean value; [b] mean ± standard deviation; [c] dynamic range; [d] processing time for a sequence of 90 images (81 contours).

- A set of 25 short-axis echocardiographic images from 13 patients was used to evaluate the performance of the proposed algorithms.
- four metrics were applied: cross-correlation coefficient (CCC), percent error (PE), error sum (ES), and edge-positioning error (EPE).

## Results

Left ventricular wall contours for good quality images.





from left to right: (a) manually-segmented; (b) optic flow method; (c) image subtraction method; (d) small sliding window method.
Bottom row presents a superposition over the manually-segmented contour.

## Conclusions

- the proposed methods are capable of providing LV-wall contour estimates with a high degree of accuracy, especially for good and medium quality images.
- The results show that it is possible to eliminate the computationally-intense process of calculating the optic flow matrix by using a smaller sliding window for temporal averaging, at the expense of a small reduction in segmentation precision.