UNSER FEATURES ESTIMATION FOR REAL-TIME TISSUE CHARACTERIZATION

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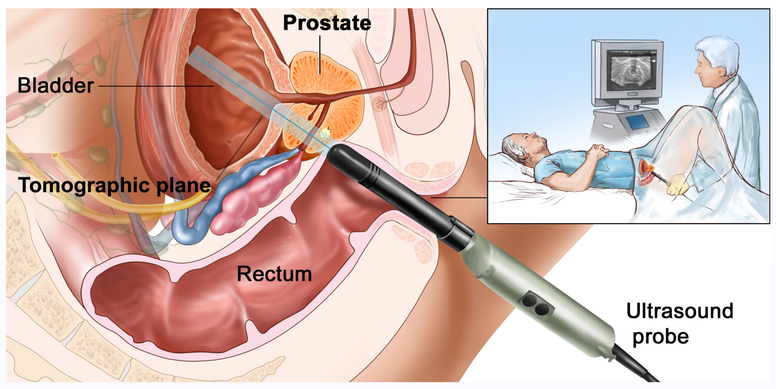
Abstract

In Ultrasound (US) guided prostate cancer detection, Computer Aided Detection (CAD) systems can be used to reduce the number of false positives. Diagnostic information must be provided with a minimum frame rate of 2-3 fps. The work proposes a parallel implementation of Unser textural features computation algorithm suitable for analyzing US images. Our CUDA implementation is effective to speed up features estimation leading to execution times suitable for real-time tissue characterization. A CAD system exploiting real-time Unser features overcomes a classical biopsy protocol.

Motivation



With more than 110.000 new cases/year in Europe, prostate cancer (PCa) is one of the most frequently diagnosed neoplasy. Unfortunately, none of the currently used diagnostic tools is reliable enough, therefore the presence of PCa can only be confirmed by a Trans-Rectal Ultrasound (TRUS) guided biopsy. Due to the limited diagnostic ability of TRUS the biopsy consists in a systematic sampling of those areas where cancer incidence is higher: accuracy growth with core number along with patient discomforts and risks probability. Computer Aided Detection (CAD) systems can be used to provide radiologist a second opinion and to reduce the number of biopsy cores without negative impinging on diagnosis accuracy.To preserve echographic examination real-time nature and to be used as biopsy guide, CAD diagnostic information must be provided with a frame rate of at least 2-3 fps.

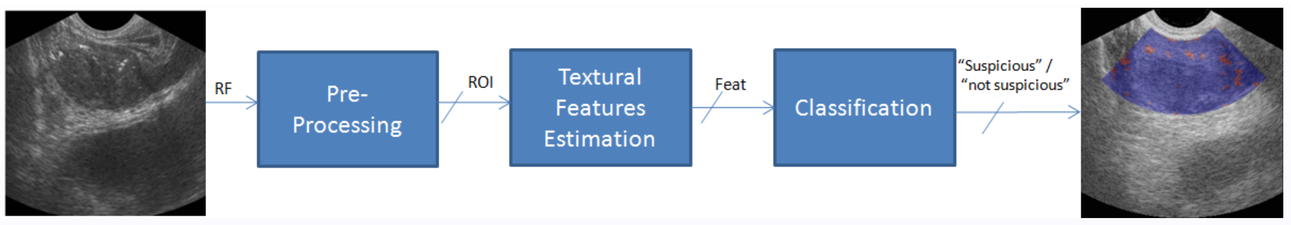
References

[1] M. Unser,Sum and difference Histograms for texture classification,in *IEEE transaction on Pattern Recognition and Machine Intelligence,vol 8, pp.118-125*,1986

[2] S. Maggio, A. Palladini, L. De Marchi, M. Alessandrini,N. Speciale,G. Masetti, Predictive Deconvolution and hybrid Feature selection for computer aided detection of Prostate Cancer, in *IEEE transactions on Medical imaging, vol 29, no. 2*, 2010

[3] N. Testoni, N. Speciale, A. Bertaccini, D. Marchiori, M. Fiorentino, F. Manferrari, R. Schiavina, R. Cividini, F. Galluzzo, S. Maggio, E. Biagi, L. Masotti, G. Masetti, G. Martorana,A retrospective study to reduce prostate biopsy cores by a real time interactive tool, 17 Congresso Nazionale SIEUN, 2010.

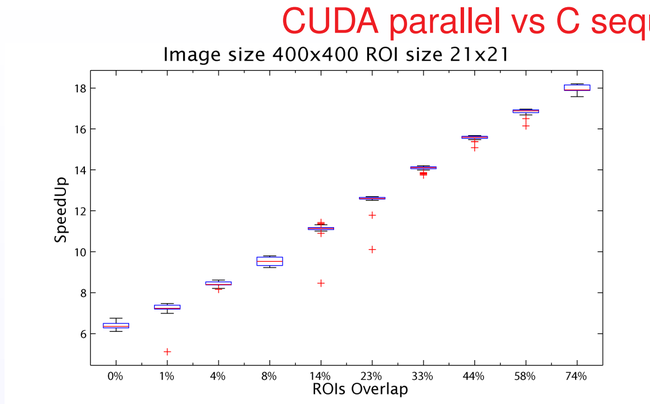
Methods



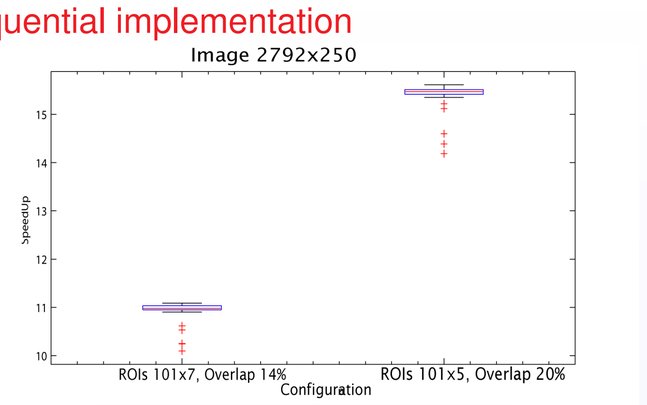
US images texture being representative of tissues microstructure, Texture Analysis (TA) can give useful information to discriminate tissues. TA introduction into a Computer Aided Detection (CAD) system processing flow needs images to be partitioned into regions of interest (ROIs) and appropriate textural features to be estimated from each ROI. ROIs can be then classified as suspicious or not-suspicious, and the obtained diagnostic information can be rendered overlapping a false color risk map to the original US image. To guarantee real-time performances the computational cost of segmentation and features estimation steps have been reduced exploiting parallel computing. Unser textural features [1] have been selected as textural parameters to analyze US images. General purpose Graphic Processing Units (GPUs) have been selected as the best architectures to enhance performance reducing both costs and development time. After US image splitting into ROIs, histograms of sum and difference of gray levels are computed for each ROI. Nine statistical parameters for each angular direction can be computed from histograms basing on a run-time selection.

Results

CUDA parallel vs C sequential implementation



ROIs overlap	0%	23%	44%	58%	74%
CPU execution time (s)	0.23	0.80	1.83	3.54	9.69
GPU execution time (s)	0.03	0.06	0.12	0.21	0.53

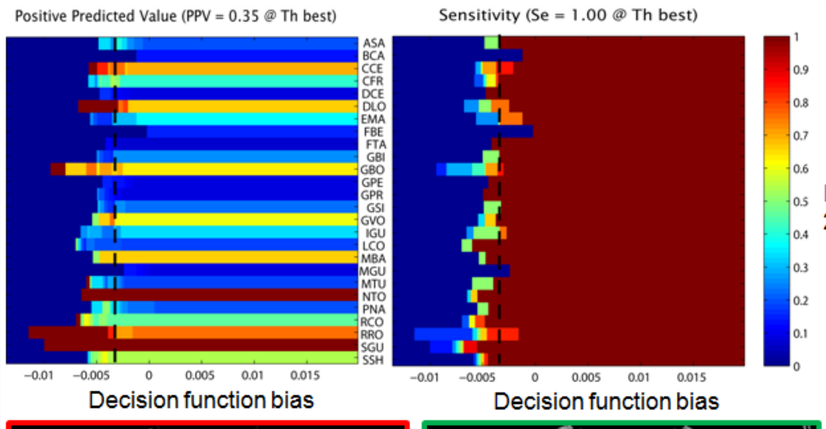


ROIs overlap	14%	20%
CPU execution time (s)	1.90	2.68
GPU execution time (s)	0.17	0.17

All 36 Unser features on a 2.4 GHz Intel Core2 Quad machine equipped with a 1.3GHz GTX280 with 240 processing units

- 12 times average speed-up across different ROIs overlap on 400x400 image segmented in 21x21 ROIs;
- 15.8 times speed-up in typical tissues characterization configurations;
- only 0.17s required for features computation in typical configurations.

Application

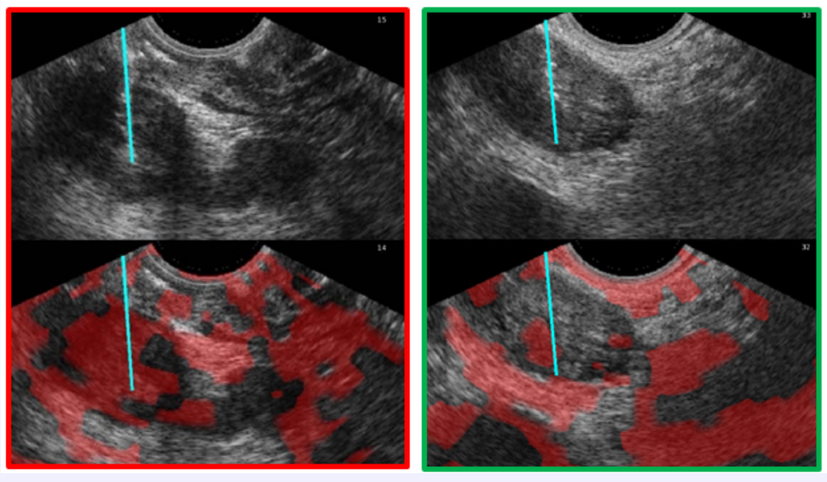


Training:
- 42 patients: 22 Uh,20 H [3]
- 9 Unser features selected by an hybrid feature selection procedure [2]

Double sextant Prostate Biopsy protocol:
24%PPV (all sampled cores as malignant)

CAD performance:
100% median SE
35% median PPV
→ 45,8% PPV improvement

Probability of correct diagnosis with N_0 cores:
$1-(1-p_0)^{N0}$
Extracted cores with CAD guide:
$N_1 = N_0 [\log(1-p_0)/\log(1-p_1)]$
→ From 12 to 7 cores



Patient	Core	Histology	CAD
SGU	7	PCa 90%	80%
SLU	13	TPB	5%

ROIs size	Classification time
10x100	25ms (40f/s)
20x200	68.5ms (15f/s)