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Improved Elasticity Imaging By Maximizing The Weighted Peaks Of The Nearest Neighbor Crosscorrelation Function

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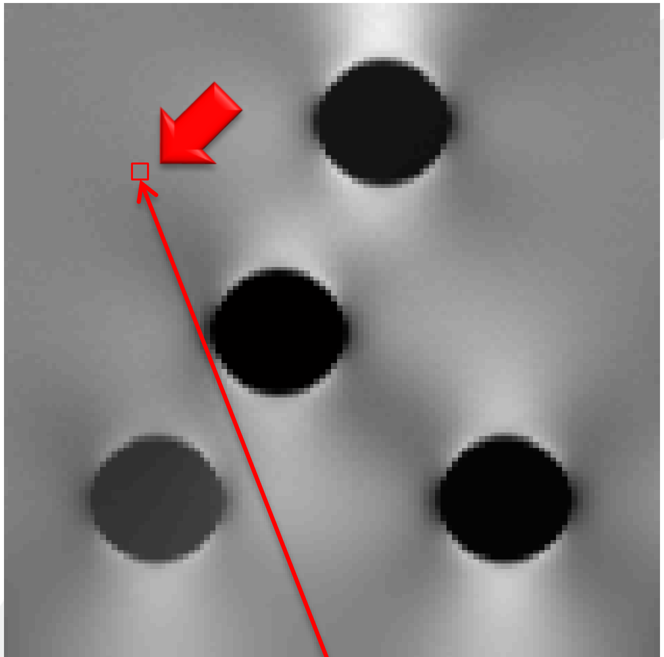
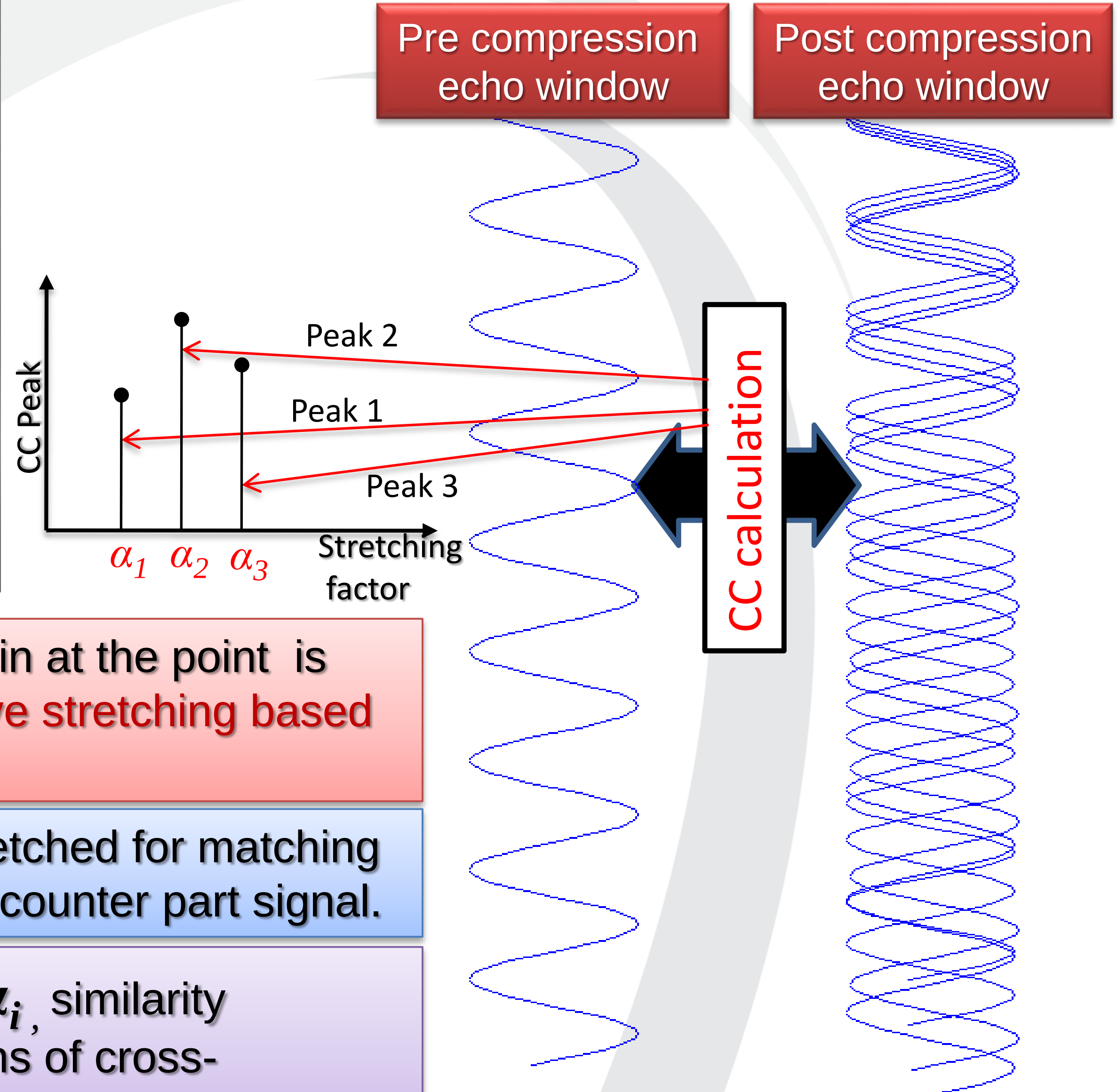
Basic Concept





We want to show, how the strain at the point is calculated in traditional adaptive stretching based method

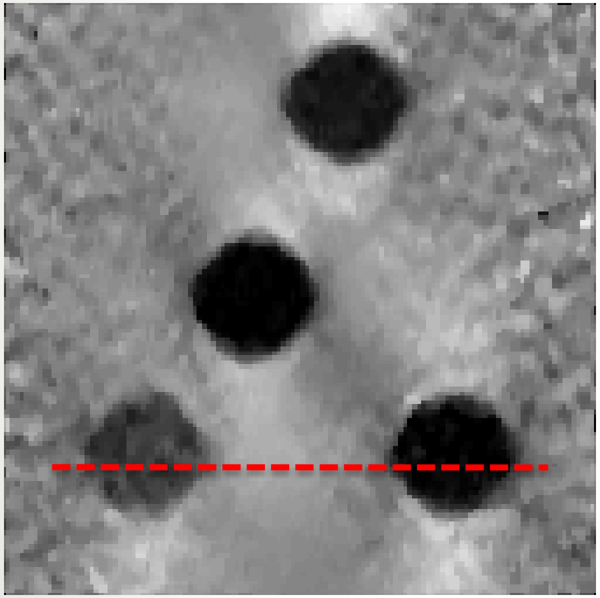
Post compression signal is stretched for matching best with the pre compression counter part signal.

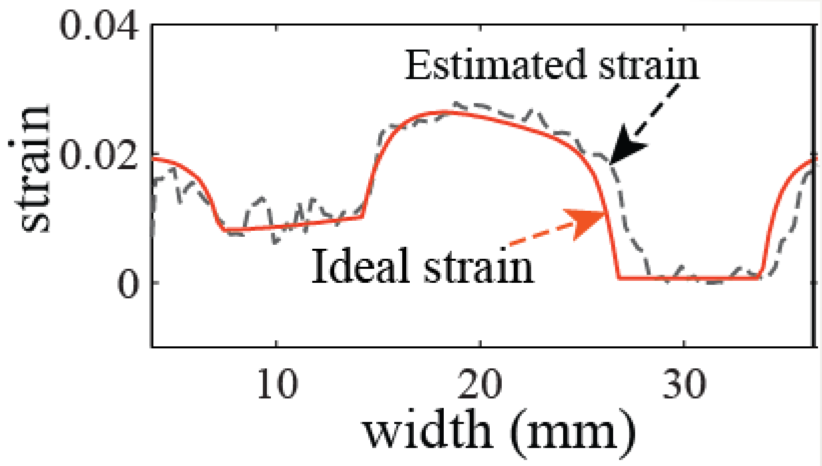
For different stretching factor $\boldsymbol{\alpha_i}$, similarity measure is calculated by means of cross-correlation(CC).

Suppose, "Peak 2" is maximum among all three peaks, then strain will be calculated from α_2 as, $strain = 1 - \alpha_2$

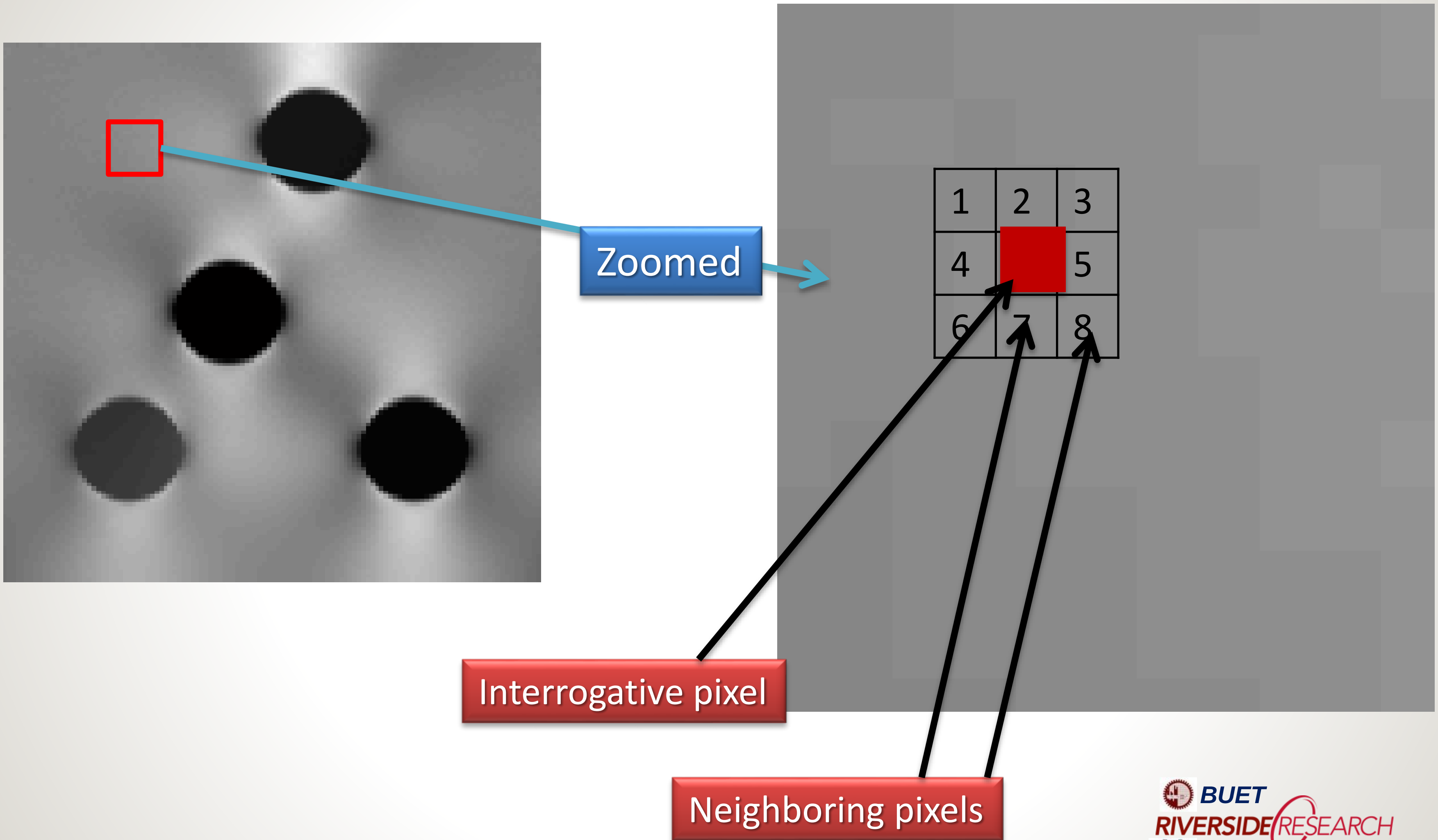
Limitation

- As each strain point (pixel) value is independently calculated, therefore, there is no strain continuity among neighboring strain values.





In our approach, we incorporate the neighboring windows along with the interrogative windows to calculate average strain in a novel way.



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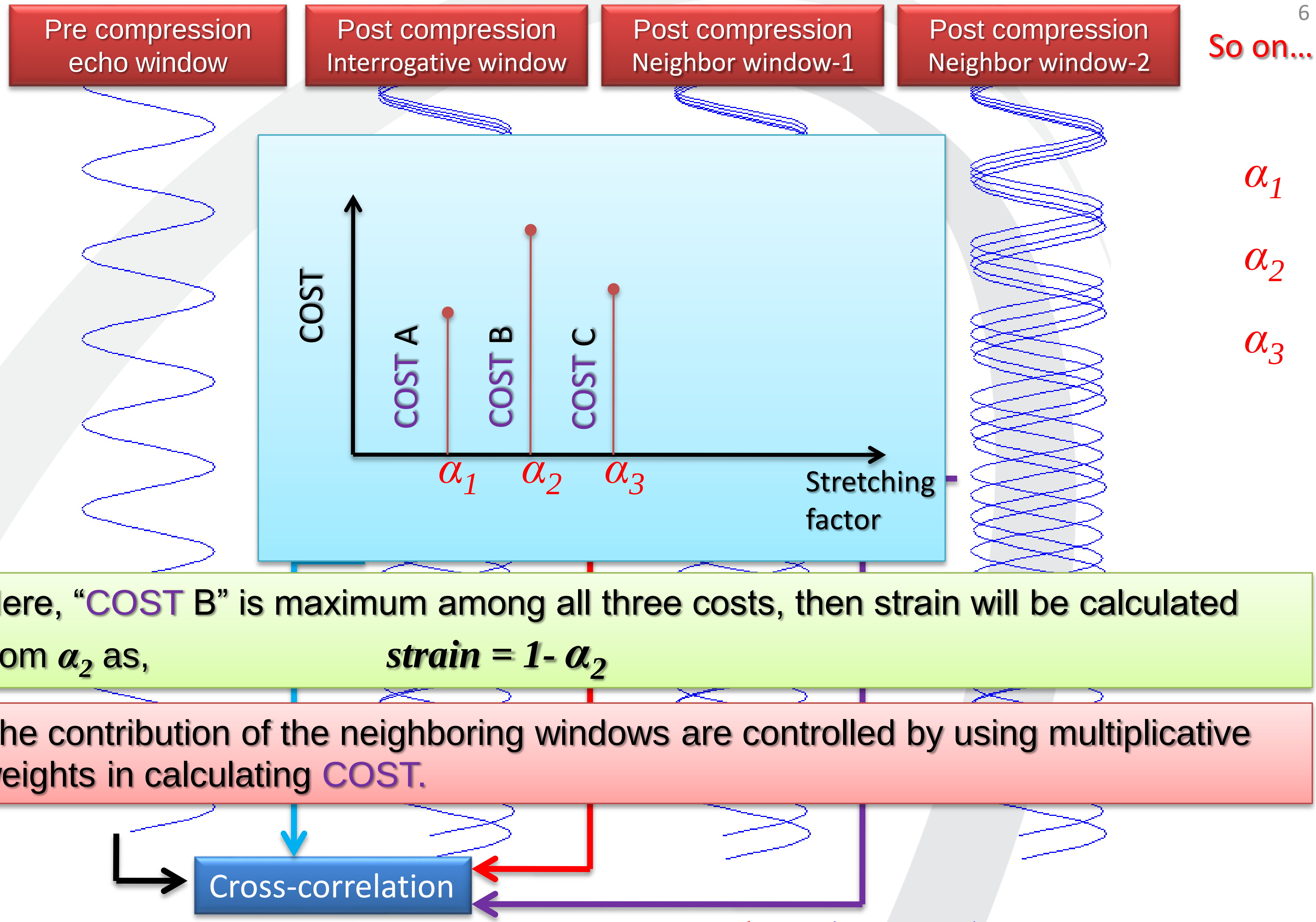

Here, "COST B" is maximum among all three costs, then strain will be calculated from α_2 as, $\quad strain = 1 - \alpha_2$

The contribution of the neighboring windows are controlled by using multiplicative weights in calculating COST.

$$w_1 Peak^{\alpha 1} + w_2 Peak^{\alpha 1} + w_3 Peak^{\alpha 1} = COST\ A$$

$$w_1 Peak^{\alpha 2} + w_2 Peak^{\alpha 2} + w_3 Peak^{\alpha 2} = COST\ B$$

Weights: $(w_1 = 1) > w_2 > w_3$

$$w_1 Peak^{\alpha 3} + w_2 Peak^{\alpha 3} + w_3 Peak^{\alpha 3} = COST\ C$$

Method:

We calculate crosscorrelation between pre- and post-compression interrogative and nearest neighbor windows for a particular stretching factor (α) at a point (i_s, j_s) on the strain map.

$$M_\alpha(i_s, j_s)$$

For average strain estimation, an exponential weight function is defined to weight the interrogative and nearest neighbor cross-correlation peaks as,

$$\omega^{(i_s, j_s)}(i, j) = e^{-\left|\lambda_a (i - i_s)\right| - \left|\lambda_l (j - j_s)\right|}$$

Here, λ_a and λ_l are the weighting factors in the axial and lateral directions, respectively

A cost function is defined from exponentially weighted neighboring pre- and post- compression rf echo cross-correlation peaks in both the axial and lateral directions to calculate AVERAGE strain for the stretching factor (α) as,

$$J_\alpha(i_s, j_s) = \sum_{i=i_s-L_a}^{i_s+L_a} \sum_{j=j_s-L_l}^{j_s+L_l} \omega^{(i_s, j_s)}(i, j) \times M_\alpha(i, j)$$

Here, L_a and L_l are the nearest neighbor (NN) factors in the axial and lateral directions, respectively

Finally Strain is calculated at a point (i_s, j_s) on the strain map as,

$$s_o(i_s, j_s) = 1 - \alpha_o^{(i_s, j_s)}$$

Where, $\alpha_o^{(i_s, j_s)} = \arg\max_\alpha \{J_\alpha^{(i_s, j_s)}\}$

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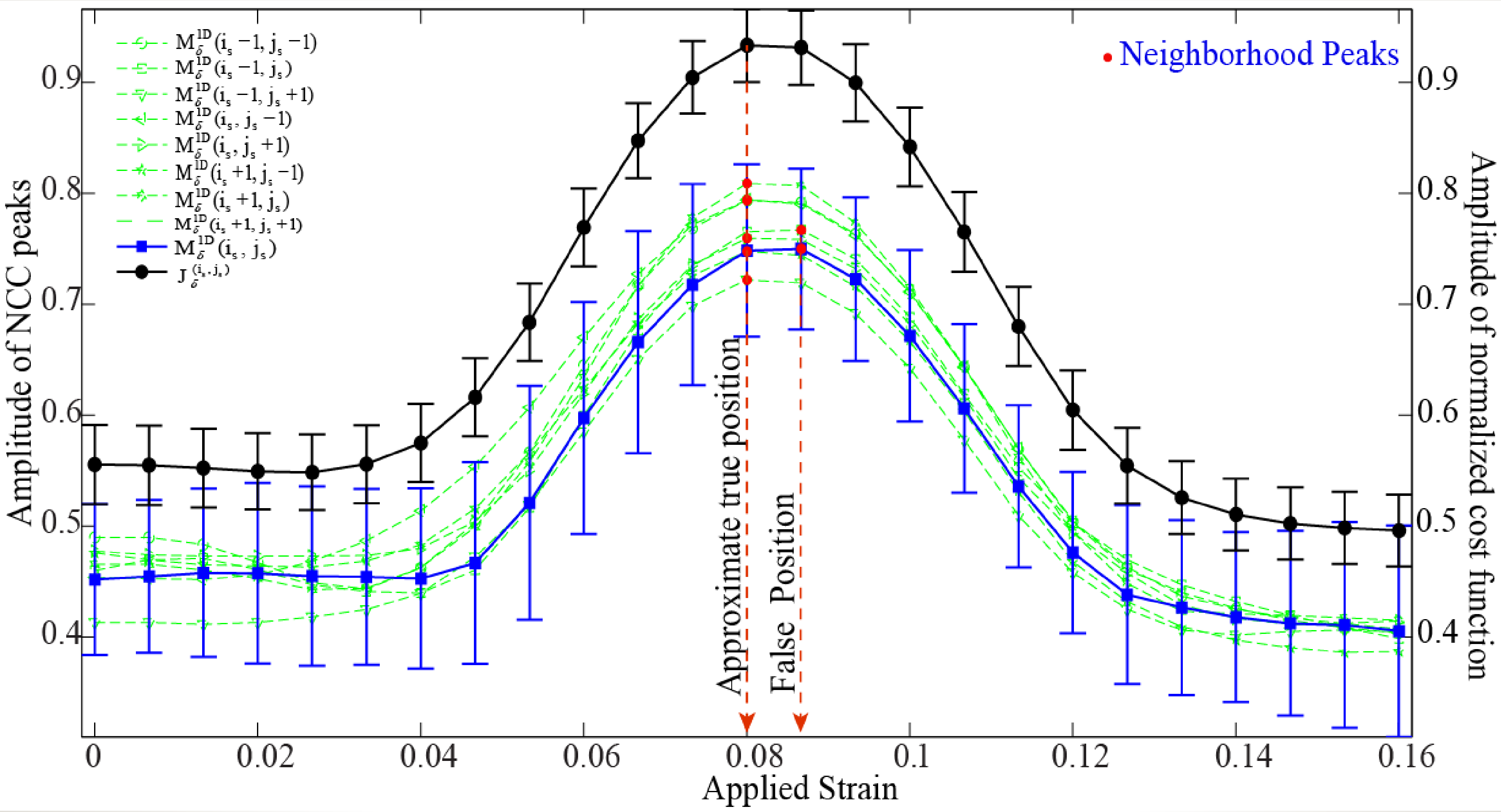
Cost function to estimate true peak



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Results: FEM simulation (1)

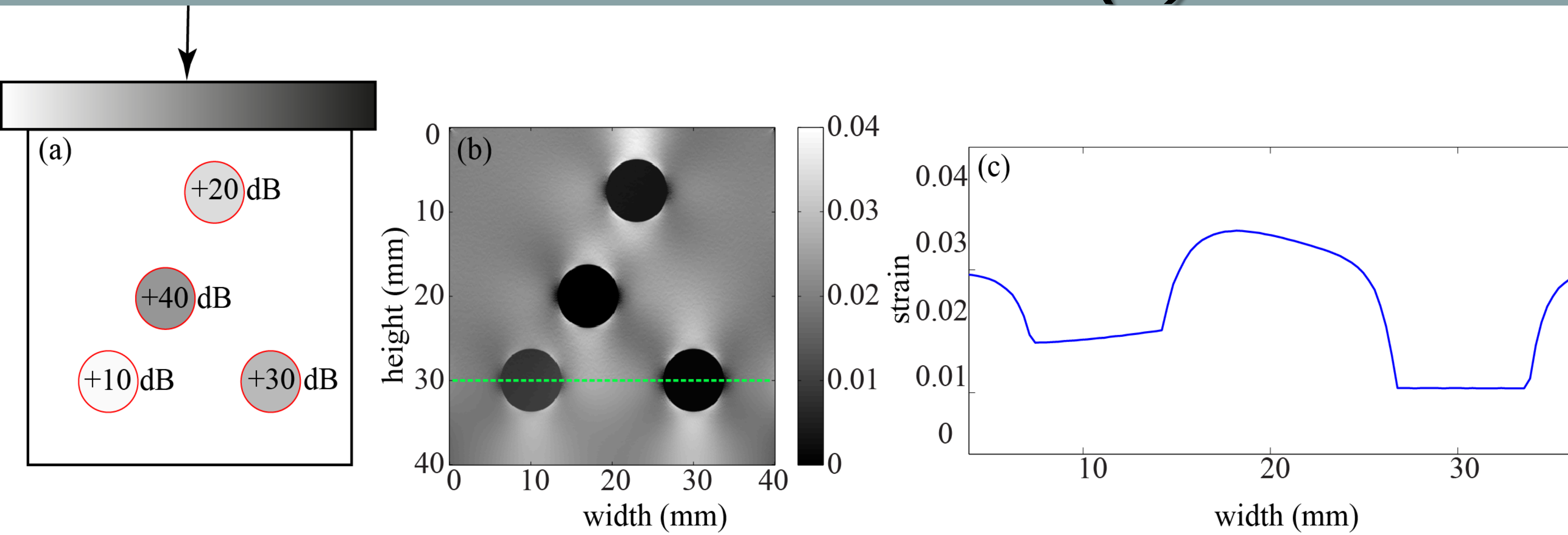


Fig. FEM simulation phantom. (a) Stiff inclusions in a homogeneous background of 60kPa, (b) corresponding ideal elastogram, (c) strain profile of the marked line in (b).

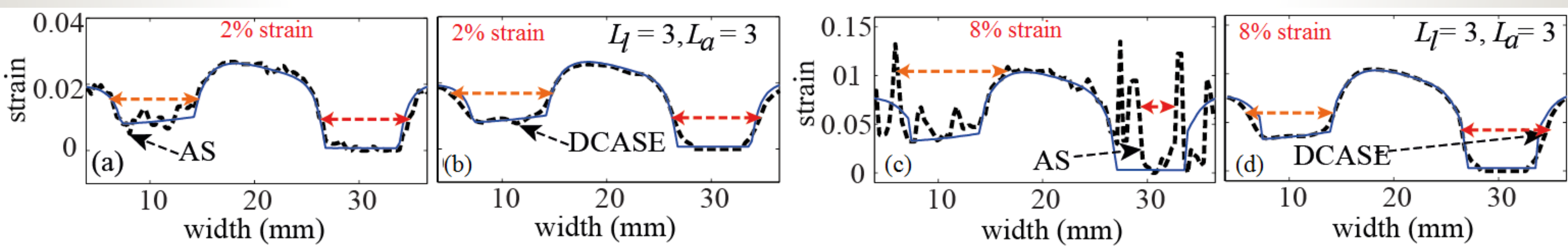
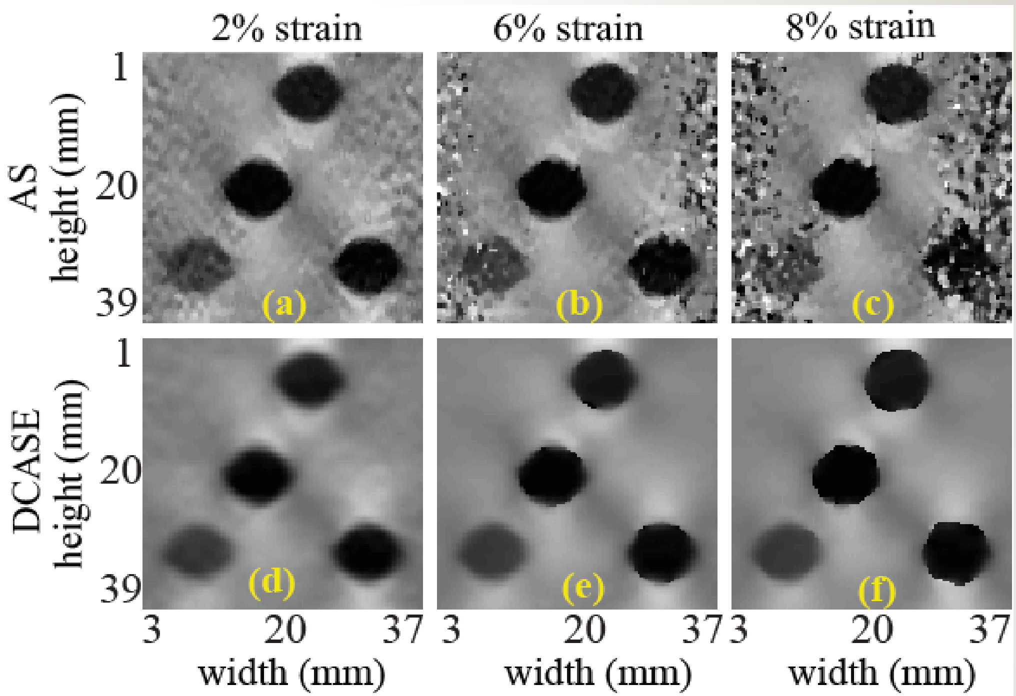
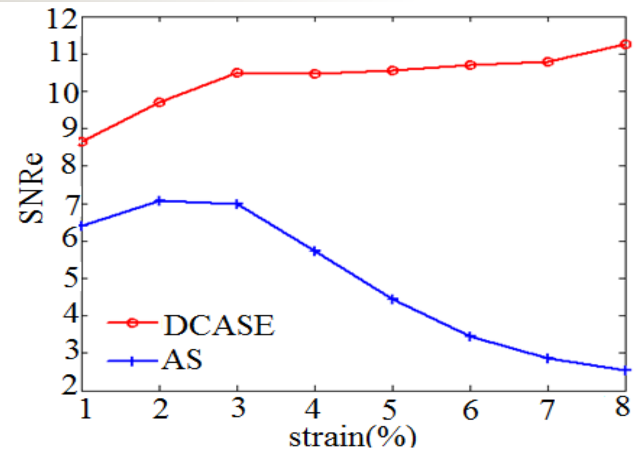


Fig. Lateral strain profiles (a-d) at a depth of 30.7mm that includes 10dB and 30dB inclusions. Comparisons with ideal strain curve are shown for (a), (c) AS and (b), (d) proposed DCASE method.

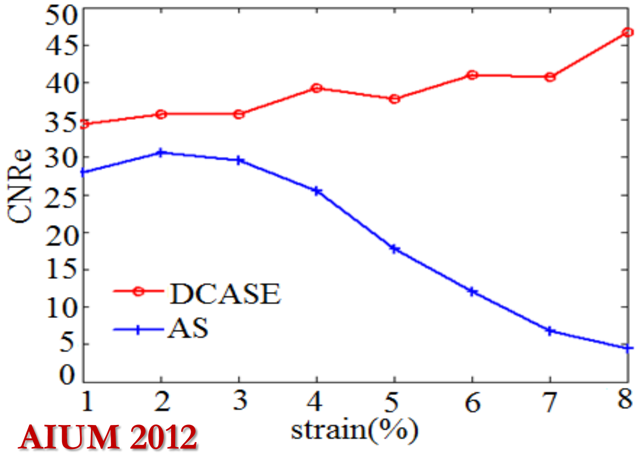
Results: *FEM simulation (2)*

Fig: Strain images of the FEM simulation phantom generated by different methods. Results (a-c) are produced by the adaptive stretching (AS) and (d-f) are produced by the proposed DCASE method with L_a*=3,* L_l*=3 and* $\lambda_a = \lambda_l = 0.25$





(a)

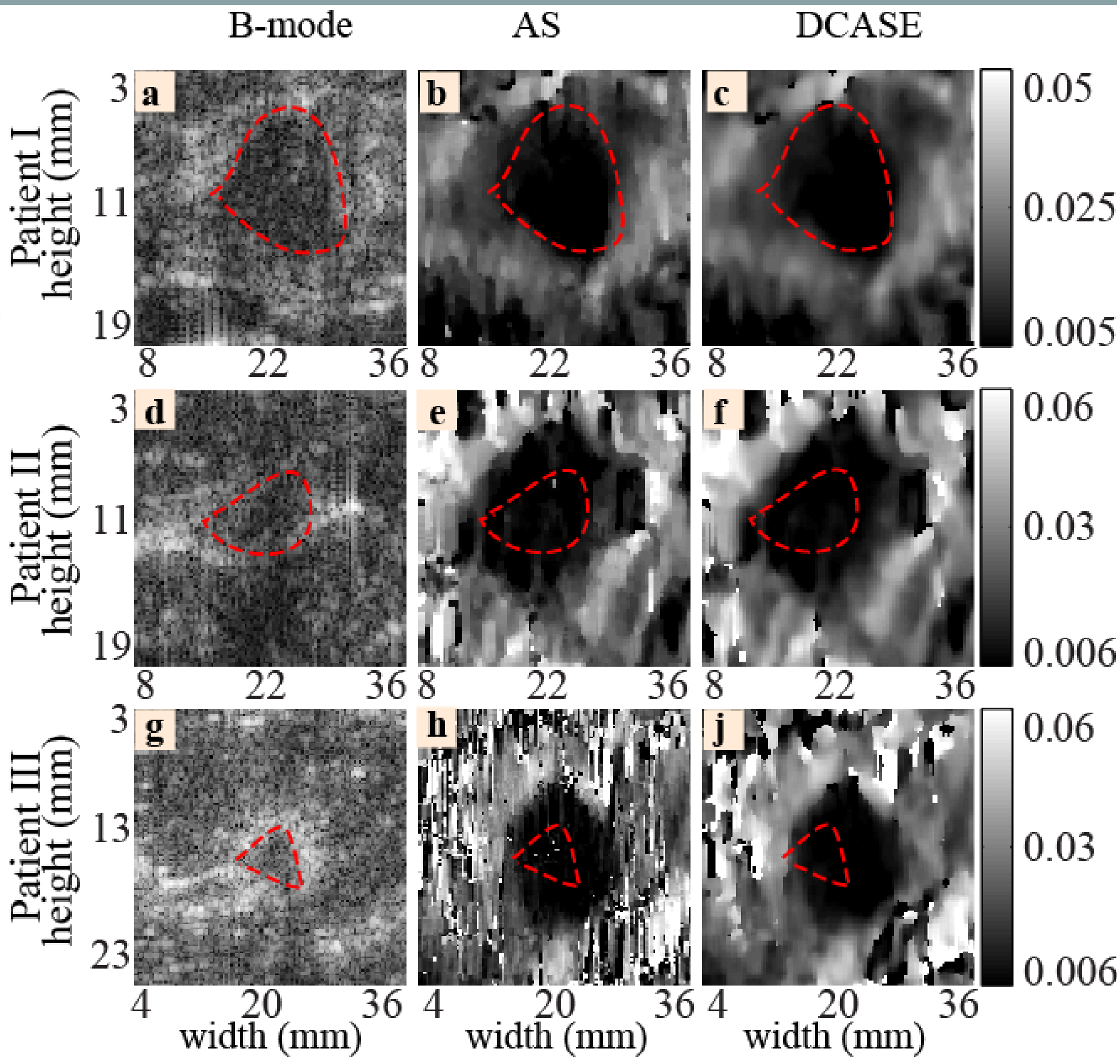


(b)

Fig: Performance comparisons of different methods using numerical indices. (a) SNRe vs. applied strain (b) CNRe vs. applied strain.

Results: Breast *in vivo*

Fig: Strain images of the in vivo breast data generated by different methods. Fig. (a, d, g) are B-mode images. Results (b, e, h) are produced by the adaptive stretching (AS) and (c, f, i) are produced by the proposed algorithm *(L_a=3, L_l=3).* $\lambda_a = \lambda_l = 0.25$



Patient	Age(years)/ Mass Specification
I	28/ Fibro adenoma
II	38/ Adenocarcinoma
III	63/ Adenocarcinoma

The size of a cancerous tissue in an ultrasonic B-mode image is smaller than that in an Elastogram. The size of the malignant objects in these images are larger than that in the B-mode images.

SUMMARY

- Proposed strain estimator
  - *in vivo* cases produce improved strain images compared to other strain estimators
  - high SNR strain image preserving lesion edge
    - Better tumor visibility
- Future work
  - make this algorithm time efficient for its real time implementation

Thank You!!!

Faculty Disclosure: **<u>No</u> relationships or affiliations exist with any commercial entities for *this* presentation**

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