Data Processing: Strain Estimation (*in vivo*)

Summary:

This data set is from patients with suspected breast cancers. The data were acquired using a Sonix-500RP (Ultrasonix Medical Corporation, Richmond BC, Canada) operating at 10MHz (nominal) at the University of Vermont Medical Center (UVM).

The scanner had real-time strain imaging installed. The clinician saved the RF data (*.rf) and the cine loop of the real-time strain sequence (*.avi).

Some frame pairs produces good strain images and some do not. Some good frame pairs are shown toward the end of the file.

How to process these files using the basic strain estimation algorithms (the routine `EstStrn.m`, written by KA used) is shown below.

File and Naming Formats:

Raw (RF) data files have *.rf extensions. Many files have corresponding *.avi files that show the strain images (videos) generated by the manufacturer supplied software package. Each *.rf file has a sequence of RF frames (3D data) that can be read using the MATLAB code `RPread.m`.

Processing:

Strain can be estimated using any “standard” strain estimation routine. The straightforward processing is as follows. Feel free to customize as needed.

```
% FROM VT003/V0254
rfseq = RPread('10-58-09.rf');
rf_pre = double(rfseq(:,:,269)); % PRE COMPRESSION
rf_pst = double(rfseq(:,:,369)); % POST COMPRESSION
% COMPUTE STRAIN MAPS USING THE COMMON ROUTINES
helpwin EstStrn
[s,d,c] = EstStrn(rf_pre,rf_pst,96,64,32,0.01,0,0.04,'G'); % GRADIENT OF
DISPLACEMENT MAP
imagesc(s), colorbar
[s,d,c] = EstStrn(rf_pre,rf_pst,96,64,32,0.01,0,0.04,'ls'); % LEAST SQUARES
imagesc(s), colorbar
[s,d,c] = EstStrn(rf_pre,rf_pst,96,64,32,0.01,0,0.04,'us'); % UNIFORM
STRETCHING
imagesc(s), colorbar
[s,d,c] = EstStrn(rf_pre,rf_pst,96,64,32,0.01,0,0.04,'lsus'); % UNIFORM
STRETCHING + LEAST SQUARES
imagesc(s), colorbar
[s,d,c] = EstStrn(rf_pre,rf_pst,96,64,32,0.01,0,0.04,'a'); % ADAPTIVE
STRETCHING
imagesc(s), colorbar
% SAMPLING FREQUENCY IS 20 MHZ (FS = 20 MHZ)
% UPSAMPLE BY 2.5 TO MAKE THE EFFECTIVE FS = 50 MHZ
% ALSO CAN UPSAMPLE BY 5 (FS = 100 MHZ)
```

```
rf_pre2 = interpft(rf_pre,2580); % UPSAMPLING BY 2.5
rf_pst2 = interpft(rf_pst,2580);
[s,d,c] = EstStrn(rf_pre2,rf_pst2,192,128,64,0.01,0,0.04,'g');
imagesc(s), colorbar
[s,d,c] = EstStrn(rf_pre2,rf_pst2,192,128,64,0.01,0,0.04,'ls');
imagesc(s), colorbar
[s,d,c] = EstStrn(rf_pre2,rf_pst2,192,128,64,0.01,0,0.04,'us');
imagesc(s), colorbar
[s,d,c] = EstStrn(rf_pre2,rf_pst2,192,128,64,0.01,0,0.04,'lsus');
imagesc(s), colorbar
[s,d,c] = EstStrn(rf_pre2,rf_pst2,192,128,64,0.01,0,0.04,'a');
imagesc(s), colorbar

% FROM VT021/V0306
rfseq = RPread('08-33-19.rf');
rf_pre = double(rfseq(:,:,85));
rf_pst = double(rfseq(:,:,84));
[s,d,c] = EstStrn(rf_pre,rf_pst,192,128,64,0.0075,0,0.015,'g');
imagesc(s), colorbar
[s,d,c] = EstStrn(rf_pre,rf_pst,192,128,64,0.0075,0,0.015,'ls');
imagesc(s), colorbar
[s,d,c] = EstStrn(rf_pre,rf_pst,192,128,64,0.0075,0,0.015,'us');
imagesc(s), colorbar
[s,d,c] = EstStrn(rf_pre,rf_pst,192,128,64,0.0075,0,0.015,'lsus');
imagesc(s), colorbar
[s,d,c] = EstStrn(rf_pre,rf_pst,192,128,64,0.005,0,0.01,'a');
imagesc(s), colorbar
% UPSAMPLE BY 2.5 TO MAKE THE EFFECTIVE FS = 50 MHZ
rf_pre2 = interpft(rf_pre,2580);
rf_pst2 = interpft(rf_pst,2580);
[s,d,c] = EstStrn(rf_pre2,rf_pst2,192,128,64,0.0075,0,0.015,'g');
figure(1), imagesc(s), colorbar
figure(2), imagesc(medfilt2(d)), colorbar
[s,d,c] = EstStrn(rf_pre2,rf_pst2,192,128,64,0.0075,0,0.015,'ls');
imagesc(s), colorbar
[s,d,c] = EstStrn(rf_pre2,rf_pst2,192,128,64,0.0075,0,0.015,'us');
imagesc(s), colorbar
[s,d,c] = EstStrn(rf_pre2,rf_pst2,192,128,64,0.0075,0,0.015,'lsus');
imagesc(s), colorbar
[s,d,c] = EstStrn(rf_pre2,rf_pst2,192,128,64,0.005,0,0.01,'a');
imagesc(s), colorbar
imagesc(medfilt2(d)), colorbar
imagesc(medfilt2(d,[5 5])), colorbar

% VT0019/V0301
rfseq = RPread('10-40-02.rf');
rf_pre = double(rfseq(:,:,85));
rf_pst = double(rfseq(:,:,84));
[s,d,c] = EstStrn(rf_pre,rf_pst,96,64,32,0.005,0,0.01,'g');
imagesc(s), colorbar
```

```
[s,d,c] = EstStrn(rf_pre,rf_pst,96,64,32,0.005,0,0.01,'ls');
imagesc(s), colorbar
[s,d,c] = EstStrn(rf_pre,rf_pst,96,64,32,0.005,0,0.01,'a');
imagesc(s), colorbar
% UPSAMPLE BY 2.5 TO MAKE THE EFFECTIVE FS = 50 MHZ
rf_pre2 = interpft(rf_pre,2580);
rf_pst2 = interpft(rf_pst,2580);
[s,d,c] = EstStrn(rf_pre2,rf_pst2,192,128,64,0.005,0,0.01,'g');
imagesc(s), colorbar
[s,d,c] = EstStrn(rf_pre2,rf_pst2,192,128,64,0.005,0,0.01,'ls');
imagesc(s), colorbar
[s,d,c] = EstStrn(rf_pre2,rf_pst2,192,128,64,0.005,0,0.01,'a');
imagesc(s), colorbar

% VT022/V0307
rfseq = RPread('13-40-57.rf');
rf_pre = double(rfseq(:,:,24));
rf_pst = double(rfseq(:,:,124));
[s,d,c] = EstStrn(rf_pre,rf_pst,96,64,32,0.01,0,0.025,'g');
imagesc(s), colorbar
[s,d,c] = EstStrn(rf_pre,rf_pst,96,64,32,0.01,0,0.025,'us');
imagesc(s), colorbar
[s,d,c] = EstStrn(rf_pre,rf_pst,96,64,32,0.01,0,0.025,'ls');
imagesc(s), colorbar
[s,d,c] = EstStrn(rf_pre,rf_pst,96,64,32,0.01,0,0.025,'a');
imagesc(s), colorbar
rf_pre2 = interpft(rf_pre,2580);
rf_pst2 = interpft(rf_pst,2580);
% UPSAMPLE BY 2.5 TO MAKE THE EFFECTIVE FS = 50 MHZ
rf_pre2 = interpft(rf_pre,2580);
rf_pst2 = interpft(rf_pst,2580);
[s,d,c] = EstStrn(rf_pre2,rf_pst2,192,128,64,0.01,0,0.025,'g');
imagesc(s), colorbar
[s,d,c] = EstStrn(rf_pre2,rf_pst2,192,128,64,0.01,0,0.025,'ls');
imagesc(s), colorbar
[s,d,c] = EstStrn(rf_pre2,rf_pst2,192,128,64,0.01,0,0.025,'us');
imagesc(s), colorbar
[s,d,c] = EstStrn(rf_pre2,rf_pst2,192,128,64,0.01,0,0.025,'lsus');
imagesc(s), colorbar
[s,d,c] = EstStrn(rf_pre2,rf_pst2,192,128,64,0.01,0,0.025,'a');
imagesc(s), colorbar
```

"Good" frame pairs:

1. Directory: Breast data New\VT003\V0254\
   File name: `10-58-09.rf`
   Frame No.: Pre-269, post-369

2. Directory: Breast data New\VT019\V0301\
   File name: `10-40-02.rf`

Frame No.: Pre-291, post-366

3. Directory: Breast data New\VT021\V0306\
   File name: `08-33-19.rf`
   Frame No.: Pre-85, post-84
4. Directory: Breast data New\VT022\V0307\
   File name: `13-40-57.rf`
   Frame No.: Pre-24, post-124