DENOISING PICTURES OF INSPECTED METALLIC SURFACES TO IDENTIFY SURFACE DEFECTS.

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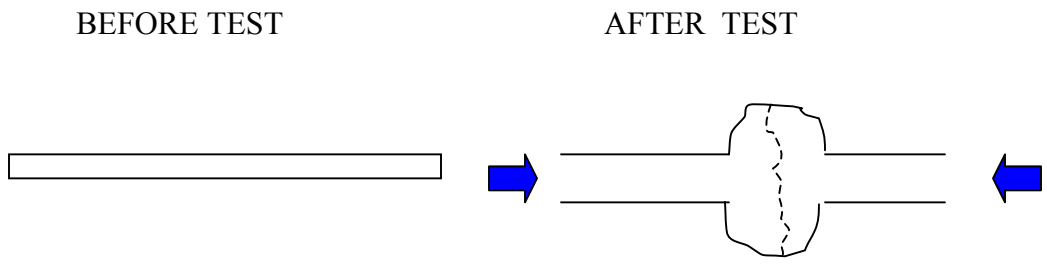
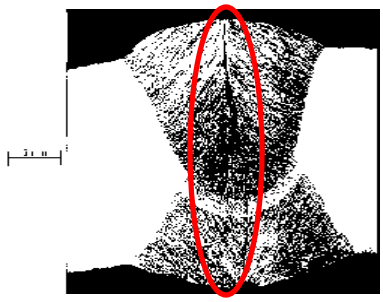
In industries where steel products are manufactured by some rolling or extrusion operation, it is not trivial to detect the presence of defects on the surface of the product. One such defect is called a 'seam', which is essentially a type of crack along the surface of the metal and can be discovered only when a specific test called a 'hot upset test' is performed. To perform this test, a sample piece of the product is pressed from two ends under high temperature and consequently there is a bulge at the middle (See figure-1). If there is a 'seam', it will be evident from a crack along that bulge. However, quite often experts receive pictures as an evidence of such tests but are unable to reach a conclusion owing to the high degree of noise in the picture. The Bayesian technique of de-noising using Ising priors can prove to be quite handy in such a scenario.

FIGURE-1 : HOT UPSET TESTING

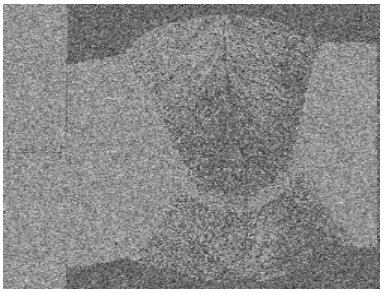


To demonstrate the usefulness of the technique, we obtain a picture of seam, where the crack is clearly visible, and superimpose noise on it so that the crack becomes almost invisible. Then we de-noise the picture using a Bayesian method with Ising priors (different J's) and it is seen that the results are reasonable.

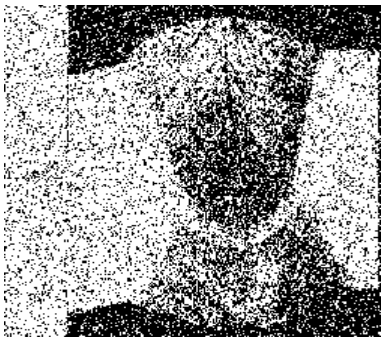
ORIGINAL PICTURE: Note the crack along the center

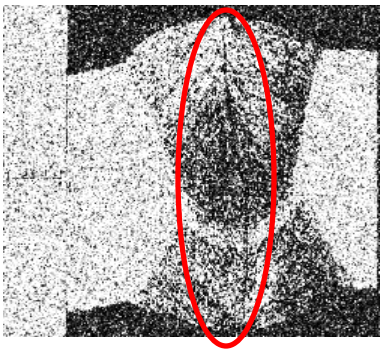


NOISY PICTURE: Crack not clearly visible



186,0000 iterations with J=0.25: crack now visible





200,0000 iterations with
J=0.5: crack visible.

MATLAB CODE

```
%Denoising of seam (surface defect) : Ising Prior
 clear all
 close all
%-----------------figure defaults
disp('Denoising of seam: Ising Prior')
lw = 2;
set(0, 'DefaultAxesFontSize', 16);
fs = 14;
msize = 5;
randn('state',3) %set the seeds (state) to have
rand ('state',3) %the constancy of results

% input matrix consisting of the seam picture.

F = imread('C:/isye8843/mcodes/seam.bmp'); %or some other path...
[M,N] = size(F);
sigma = 1.25;
d = double(F); d= 2.*((d-mean(mean(d)))>0)-1; %d either -1 1
% The body of the picture
```

```
y = d + sigma*randn(size(d)); %y: noisy picture of seam, size of the noise is sigma!
%-----------------------------------------------
figure(1);
subplot(1,2,1);imagesc(d);set(gca,'Visible','off');colormap gray; axis square;
subplot(1,2,2);imagesc(y);set(gca,'Visible','off');colormap gray; axis square;
drawnow


J = 0.5; %Reciprocal Temperature...
theta = ones(M,N); %start with ones
iter=0;
figure(2);
subplot(1,2,1); hf = imagesc(theta); set(gca,'Visible','off');
colormap gray; axis square;  drawnow;
mf = zeros(M,N);
subplot(1,2,2); hm = imagesc(mf); set(gca,'Visible','off');
colormap gray; axis square; drawnow;
SS = 10000;
misfit = [];
adj = [-1 1 0 0; 0 0 -1 1];
while 1  %(iter < 10000000) %for plotting
ix = ceil( N * rand(1) ); iy = ceil( M * rand(1) );
pos = iy + M*(ix-1);
thetap = -theta(pos);
LikRat = exp(y(pos)*(thetap - theta(pos))/sigma.^2);
neighborhood = pos + [-1,1,-M,M];
neighborhood(find([iy==1,iy==M,ix==1,ix==N])) = [];
disagree = sum(theta(neighborhood)~=theta(pos));
disagreep = sum(theta(neighborhood)~=thetap);
DelLogPr = 2 * J * (disagree - disagreep);
alpha = exp(DelLogPr) * LikRat;
  if rand < alpha
     theta(pos) = thetap;
  end
iter = iter + 1;
  if rem(iter,SS) == 0,
      mf = mf+theta; NS = iter/SS; iter
      set(hf,'CData',theta);
      set(hm,'CData',mf); drawnow
      if iter/SS > length(misfit)
            misfit = [misfit,zeros(100,1)];
            misfit(iter/SS) = sum(sum((y-theta).^2))/sigma;
      end
   end
end
```