VLFeat Library-based SIFT Demo

This script uses the VLFeat library to provide a demo of the SIFT feature and its use for matching. This script is used within the course "CS491/691: Autonomous Mobile Robot Design".

To use this script, you first have to install VLFeat: http://www.vlfeat.org/index.html

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Part 1: Basic SIFT functionality

Subsequently, SIFT feature extraction, its use for matching and some of its properties will be visualized.

```
pfx = fullfile(vl_root,'figures','demo') ;
randn('state',0) ;
rand('state',0) ;
figure(1) ; clf ;
```

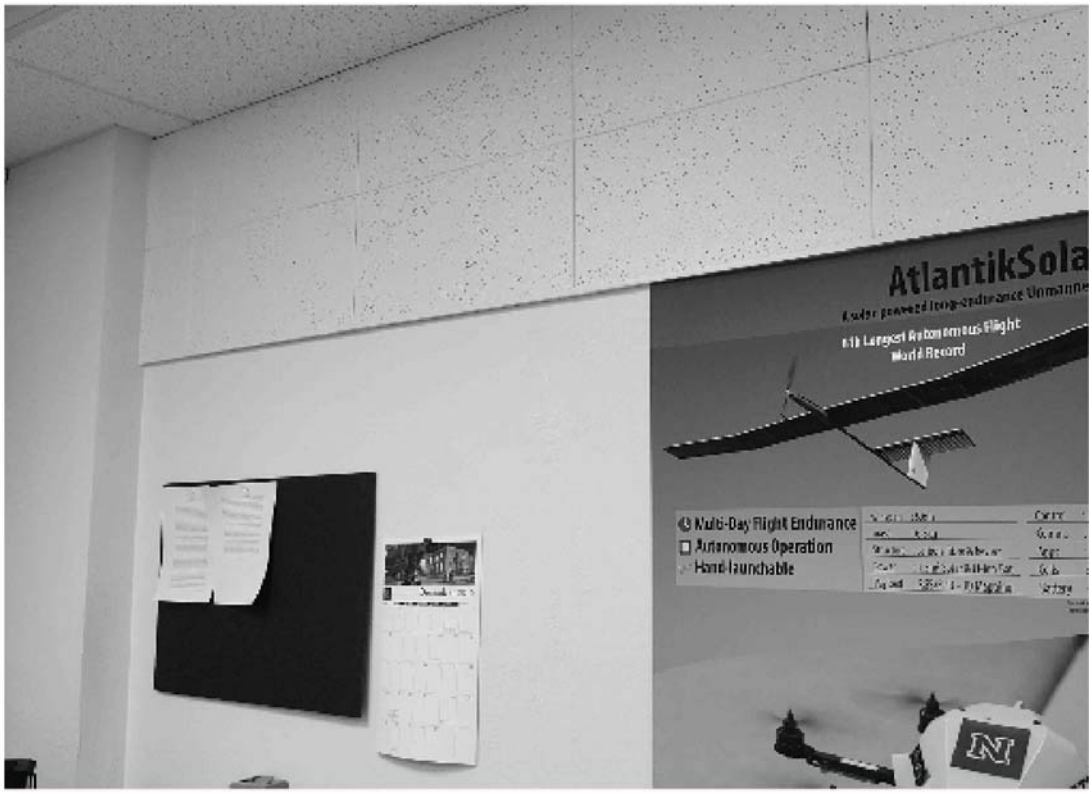
Load a Figure

```
I = imread(fullfile(vl_root,'data','im_a.jpg')) ;

image(I) ; colormap gray ;
axis equal ; axis off ; axis tight ;
```

Convert to the required format

The **vl_sift** command requires a single precision gray scale image. It also expects the range to be normalized in the [0,255] interval (while this is not strictly required, the default values of some internal thresholds are tuned for this case). The image `I` is converted in the appropriate format by

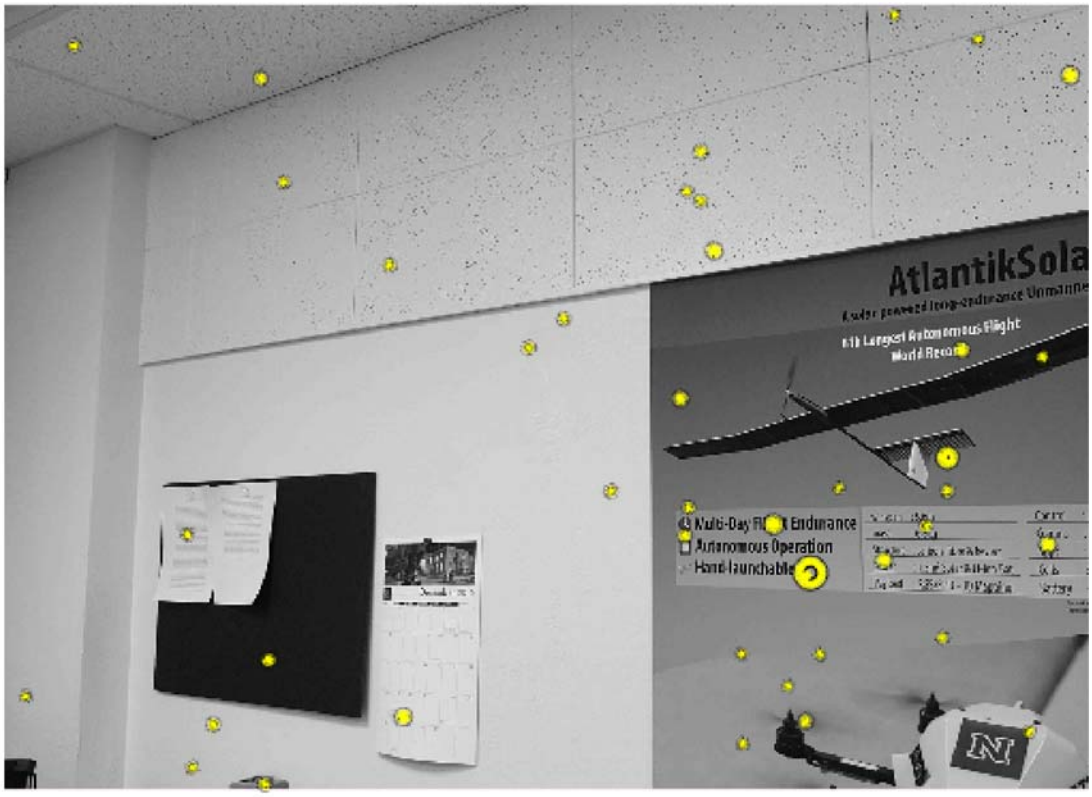
```
I = single(rgb2gray(I)) ;

clf ; imagesc(I)
axis equal ; axis off ; axis tight ;
```



Run SIFT

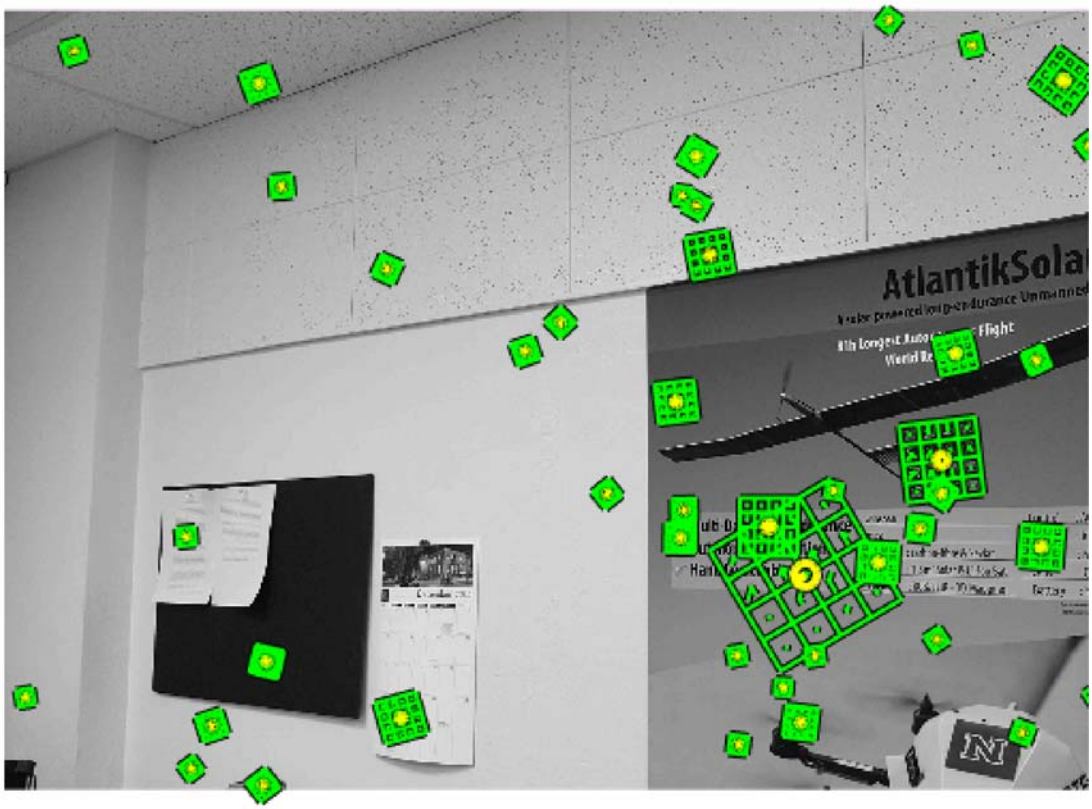
The matrix `f` has a column for each frame. A frame is a disk of center `f(1:2)`, scale `f(3)` and orientation `f(4)` . We visualize a random selection of 50 features by:

```
[f,d] = vl_sift(I) ;

hold on ;
perm = randperm(size(f,2)) ;
sel  = perm(1:50) ;
h1   = vl_plotframe(f(:,sel)) ; set(h1,'color','k','linewidth',3) ;
h2   = vl_plotframe(f(:,sel)) ; set(h2,'color','y','linewidth',2) ;
```



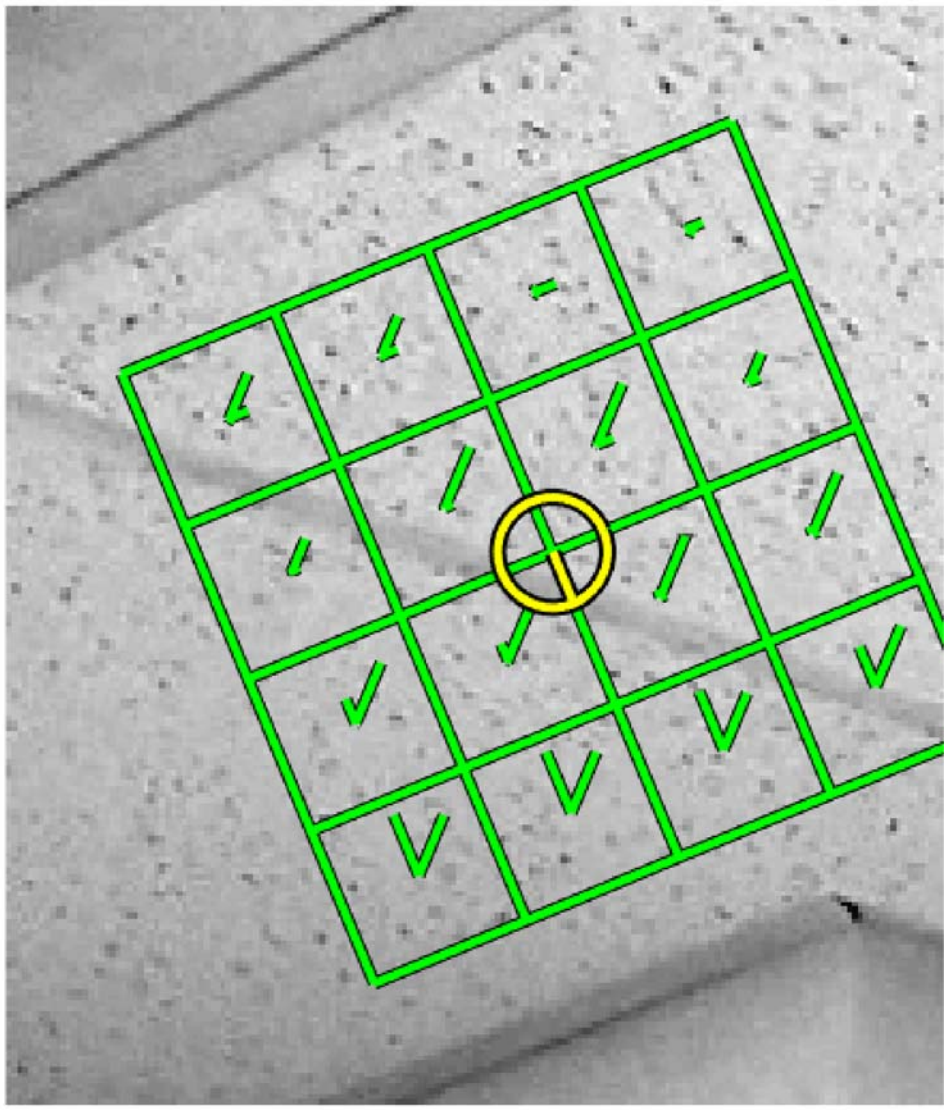
We can also overlay the descriptors by

```
delete([h1 h2]);

h3 = vl_plotsiftdescriptor(d(:,sel),f(:,sel)) ;
set(h3,'color','k','linewidth',2) ;
h4 = vl_plotsiftdescriptor(d(:,sel),f(:,sel)) ;
set(h4,'color','g','linewidth',1) ;
h1   = vl_plotframe(f(:,sel)) ; set(h1,'color','k','linewidth',3) ;
h2   = vl_plotframe(f(:,sel)) ; set(h2,'color','y','linewidth',2) ;
```



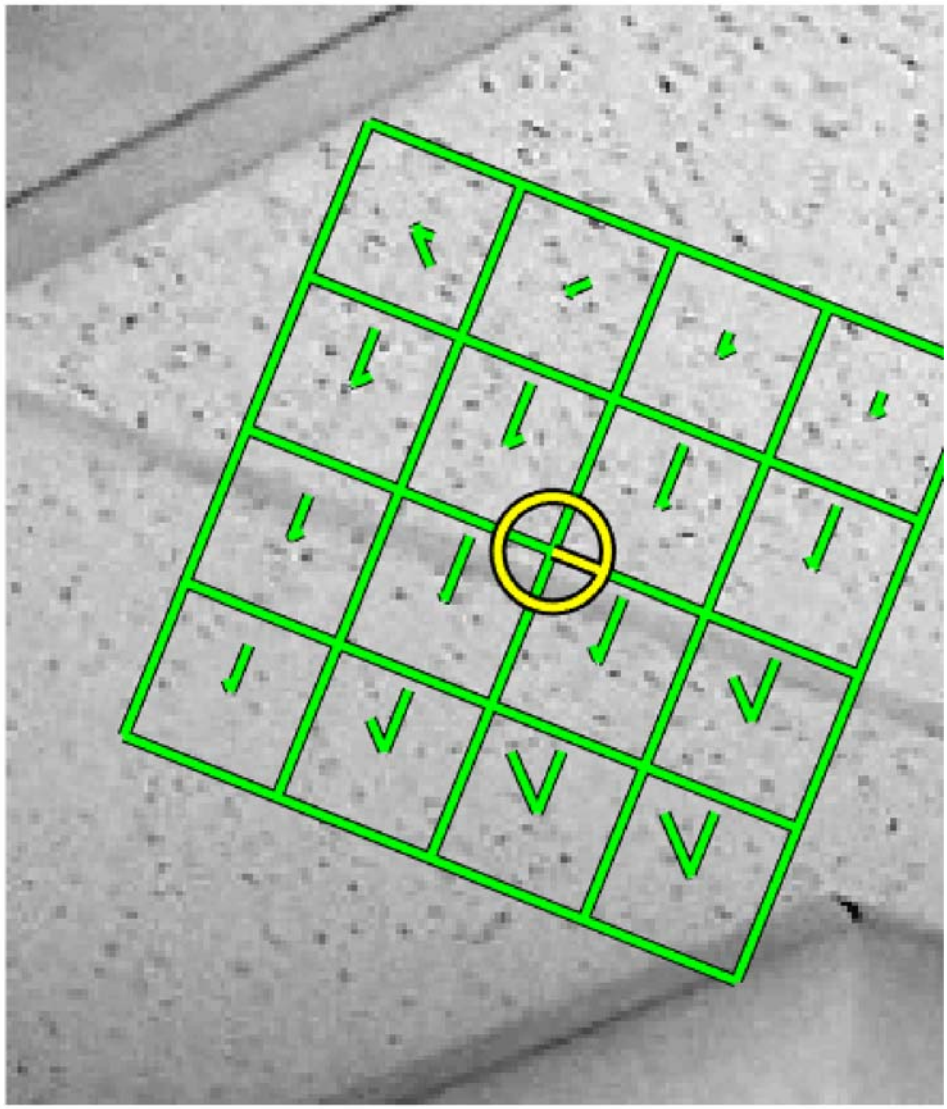
Custom Keypoint

```
clf ; imagesc(I(1:200,1:200,:))
axis equal ; axis off ; axis tight ;
hold on;

fc = [100;100;10;-pi/8] ;
[f,d] = vl_sift(I,'frames',fc) ;

h3   = vl_plotsiftdescriptor(d,f) ;  set(h3,'color','k','linewidth',3) ;
h4   = vl_plotsiftdescriptor(d,f) ;  set(h4,'color','g','linewidth',2) ;
h1   = vl_plotframe(f) ; set(h1,'color','k','linewidth',4) ;
h2   = vl_plotframe(f) ; set(h2,'color','y','linewidth',2) ;
```



Custom Keypoints with orientations

```
fc = [100;100;10;0] ;
[f,d] = vl_sift(I,'frames',fc,'orientations') ;

delete([h1 h2 h3 h4]) ;

h3   = vl_plotsiftdescriptor(d,f) ;  set(h3,'color','k', 'linewidth',3) ;
h4   = vl_plotsiftdescriptor(d,f) ;  set(h4,'color','g', 'linewidth',2) ;
h1   = vl_plotframe(f) ; set(h1,'color','k','linewidth',4) ;
h2   = vl_plotframe(f) ; set(h2,'color','y','linewidth',2) ;
```



Part 2: SIFT Basic Matching

SIFT descriptors are often used find similar regions in two images. `vl_ubcmatch` implements a basic matching algorithm. Let `Ia` and `Ib` be images of the same object or scene. We extract and match the descriptors by:

```
pfx = fullfile(vl_root,'figures','demo') ;
randn('state',0) ;
rand('state',0) ;
figure(1) ; clf ;
```

Create Image Pair

```
Ia = imread(fullfile(vl_root,'data','im_a.jpg')) ;
```

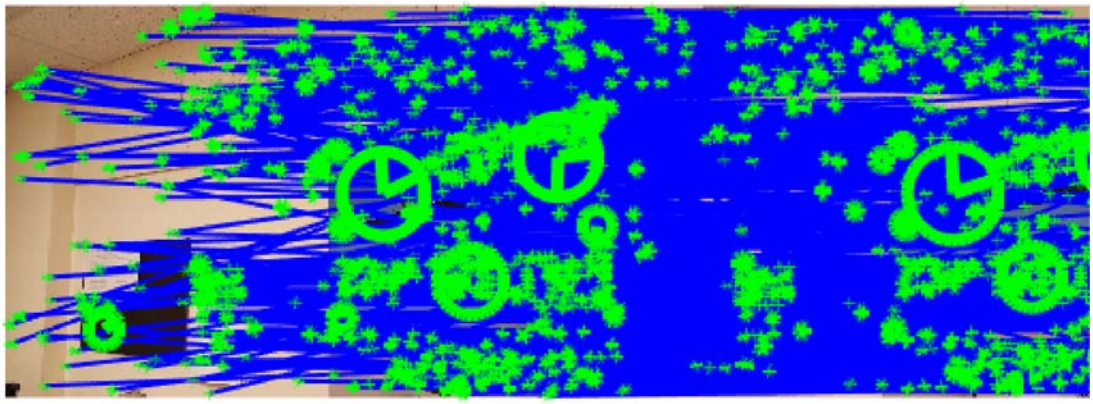
```
Ib = imread(fullfile(vl_root,'data','im_b.jpg')) ;
```

Extract Features and Match

```
[fa,da] = vl_sift(im2single(rgb2gray(Ia))) ;
[fb,db] = vl_sift(im2single(rgb2gray(Ib))) ;

[matches, scores] = vl_ubcmatch(da,db) ;

[drop, perm] = sort(scores, 'descend') ;
matches = matches(:, perm) ;
scores  = scores(perm) ;

figure(1) ; clf ;
imagesc(cat(2, Ia, Ib)) ;
axis image off ;
```


```
vl_demo_print('sift_match_1', 1) ;

figure(2) ; clf ;
imagesc(cat(2, Ia, Ib)) ;

xa = fa(1,matches(1,:)) ;
xb = fb(1,matches(2,:)) + size(Ia,2) ;
ya = fa(2,matches(1,:)) ;
yb = fb(2,matches(2,:)) ;

hold on ;
h = line([xa ; xb], [ya ; yb]) ;
set(h,'linewidth', 1, 'color', 'b') ;
```

```
vl_plotframe(fa(:,matches(1,:))) ;
fb(1,:) = fb(1,:) + size(Ia,2) ;
vl_plotframe(fb(:,matches(2,:))) ;
axis image off ;
```



For each descriptor in `da`, **vl_ubcmatch** finds the closest descriptor in `db` (as measured by the L2 norm of the difference between them). The index of the original match and the closest descriptor is stored in each column of `matches` and the distance between the pair is stored in `scores`.

Matches also can be filtered for uniqueness by passing a third parameter to **vl_ubcmatch** which specifies a threshold. Here, the uniqueness of a pair is measured as the ratio of the distance between the best matching keypoint and the distance to the second best one (see **vl_ubcmatch** for further details).

Part 3: Detector parameters

The SIFT detector is controlled mainly by two parameters: the peak threshold and the (non) edge threshold.

The *peak threshold* filters peaks of the DoG scale space that are too small (in absolute value). For instance, consider a test image of 2D Gaussian blobs:

```
randn('state',0) ;
rand('state',0) ;

I = double(rand(100,500) <= .005) ;
I = (ones(100,1) * linspace(0,1,500)) .* I ;
I(:,1) = 0 ; I(:,end) = 0 ;
I(1,:) = 0 ; I(end,:) = 0 ;
I = 2*pi*4^2 * vl_imsmooth(I,4) ;
I = single(255 * I) ;

figure(1) ; clf ;
imagesc(I) ; colormap gray ;
axis equal ;  axis off; axis tight ;
hold on ;
```

We run the detector with peak threshold peak_thresh by setting the relevant parameters in the vl_sift the command. Similarly we run the detector with edge threshold edge_thresh by setting the relevant parameters in the vl_sift command. We tend to obtain more features as edge_thresh is increased.

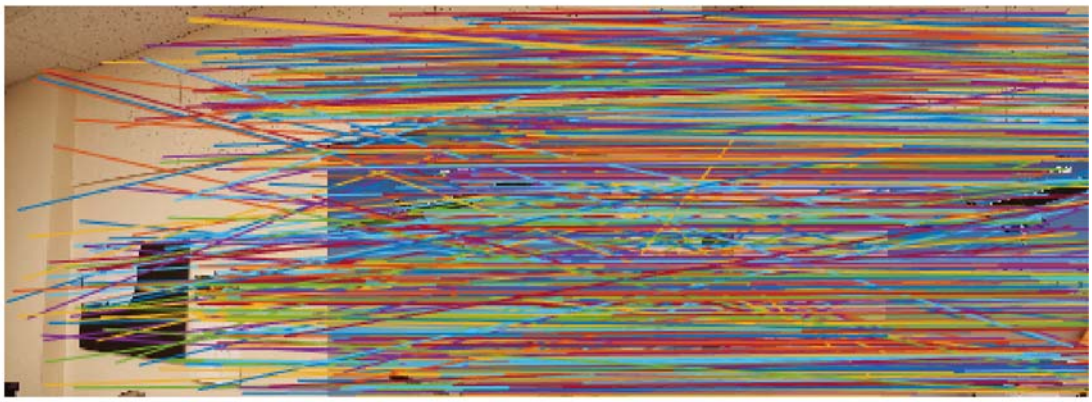
```
tpr = [0 10 20 30] ;
for tp=tpr
  f = vl_sift(I, ...
            'PeakThresh',   tp,    ...
            'EdgeThresh',   10000, ...
            'FirstOctave', -1) ;

  h1 = vl_plotframe(f) ;
  set(h1,'color','k','linewidth',3) ;
  h2 = vl_plotframe(f) ;
  set(h2,'color','y','linewidth',2) ;

  vl_demo_print(sprintf('sift_peak_%d',find(tp==tpr))) ;
  pause(1)
  delete(h1) ;
  delete(h2) ;
end
```

Mosaic using SIFT - Demo

```
mosaic = sift_mosaic_demo(Ia, Ib);
```

```
Warning: Refinement disabled as fminsearch was not found.
```

1067 tentative matches



617 (57.83%) inliner matches out of 1(

Mosaic