Machine Vision: Homework #2

[redacted]

. Homographies Part I

A) 07_Practical_Homographies\Part1\practical1.m

In figure 1-1, the red points may represent some points in one image, and the blue points are the corresponding points in another image. A pair of red point and blue point connected by green line means that the position (x-axis value and y-axis value) of this red point in the first image is mapping to the position (x-axis value and y-axis value) of this blue point in the second image.

In figure 1-2, the magenta points are the estimation of red points estimated from the relation between red points and blue points. The green lines show the distances between estimated values and true values.

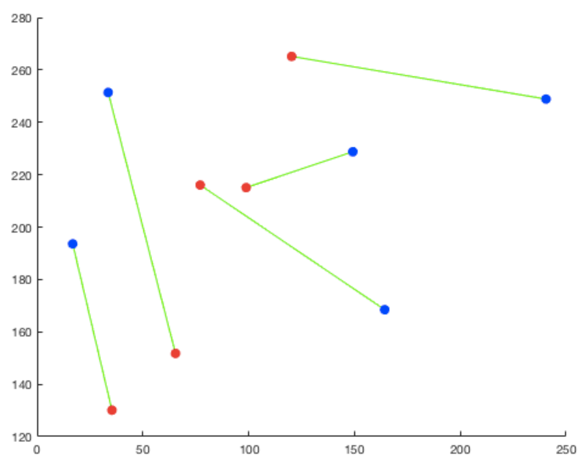

figure 1-1

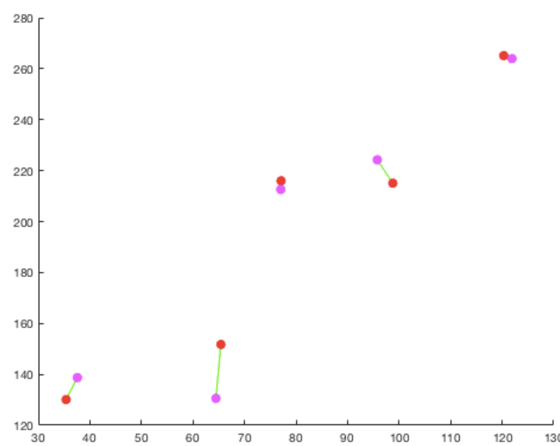

figure 1-2

TO DO 1. Adding a scaling parameter λ, and multiplying the estimated matrix HEst by λ, the result remains the same.

$$\lambda' \begin{bmatrix} x_1 \\ y_1 \\ 1 \end{bmatrix} = \lambda \begin{bmatrix} \emptyset_{11} & \emptyset_{12} & \emptyset_{13} \\ \emptyset_{21} & \emptyset_{22} & \emptyset_{23} \\ \emptyset_{31} & \emptyset_{32} & \emptyset_{33} \end{bmatrix} \begin{bmatrix} x_2 \\ y_2 \\ 1 \end{bmatrix}$$

Hence,

$$x_1 = \frac{\lambda(\emptyset_{11} * x_2 + \emptyset_{12} * y_2 + \emptyset_{13})}{\lambda(\emptyset_{31} * x_2 + \emptyset_{32} * y_2 + \emptyset_{33})} = \frac{\emptyset_{11} * x_2 + \emptyset_{12} * y_2 + \emptyset_{13}}{\emptyset_{31} * x_2 + \emptyset_{32} * y_2 + \emptyset_{33}}$$

$$y_1 = \frac{\lambda(\emptyset_{21} * x_2 + \emptyset_{22} * y_2 + \emptyset_{23})}{\lambda(\emptyset_{31} * x_2 + \emptyset_{32} * y_2 + \emptyset_{33})} = \frac{\emptyset_{21} * x_2 + \emptyset_{22} * y_2 + \emptyset_{23}}{\emptyset_{31} * x_2 + \emptyset_{32} * y_2 + \emptyset_{33}}$$

From these formulas, when mapping x1 to x2, the scaling factor λ is canceled out. Thus, no matter what value λ is, the homography still do the same thing.

TO DO 2. Using only the first four points of pts1Cart, we can still get the result pts2EstCart and pts2EstCart is exactly the same as pts2Cart. Although there are 9 parameters in H, since homography is ambiguous up to scale (we can assume that one of the 9 parameters can be random value as long as the relation between it and the other 8 parameters is fixed). Hence, the freedom degree is 8, which means we just need 8 equations (4 points) to get the unique solution.

Results:

```
pts2Cart =

  136.7866   44.6275   62.3151   76.7737
  247.6280  133.2341  155.4415  209.5670


nPoint =

     4


pts2EstHom =

   -0.3367   -0.2475   -0.5256    0.0051
   -0.6096   -0.7390   -1.3112    0.0141
   -0.0025   -0.0055   -0.0084    0.0001


pts2EstCart =

  136.7866   44.6275   62.3151   76.7737
  247.6280  133.2341  155.4415  209.5670
```

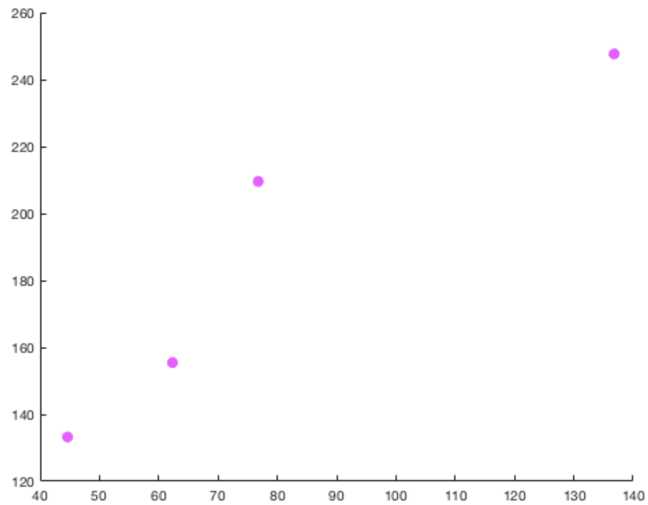

figure 1-3

B) 07_Practical_Homographies\Part1\practical1B.m

figure 2-1

Figure 2-1 shows the image1. The red points are the matching points between image1 and image2 and the magenta points are the matching points between image1 and image3 in image1.

figure 2-2

Figure 2-2 shows the image2. The red points are the matching points between image1 and image2 in image2.

figure 2-3

Figure 2-3 shows the image3. The magenta points are the matching points between image1 and image3 in image3.

figure 2-4

Figure 2-4 shows the result of mapping the image2 into the frame of reference of the image1.By computing the relation (H matrix) of several matching points between image1 and image2, we can make use of this relation to find out all matching points between image1 and image2 and add these matching points to the frame of reference of the image1.

figure 2-5

Figure 2-5 shows a panorama of image1, image2 and image3. After adding matching points in image2 to image1, by computing the relation (H matrix) of several matching points between image1 and image3, we can find out all matching points between image1 and image3 and add these matching points to the frame of reference of the image1.

Homographies Part II

C) 07_Practical_Homographies\Part2\practical2.m

Our goal in practical2 is to estimate the extrinsic matrix and the following results show the estimated extrinsic matrix TEst. If values of TEst are closer to the true values of extrinsic matrix T, our estimation is more accurate. As showing in the following result, our estimator TEst is quite close to the real value T, hence, our estimation is accurate to some extent.

Results:

```
T =


    0.9851   -0.0492    0.1619   46.0000
   -0.1623   -0.5520    0.8181   70.0000
```

```
    0.0490   -0.8324   -0.5518  500.8900
         0         0         0    1.0000


TEst =

    0.9844   -0.0410    0.1712   45.4986
   -0.1645   -0.5601    0.8119   69.3026
    0.0626   -0.8274   -0.5581  494.6129
         0         0         0    1.0000
```

D) 07_Practical_Homographies\Part2\ practical2b.m

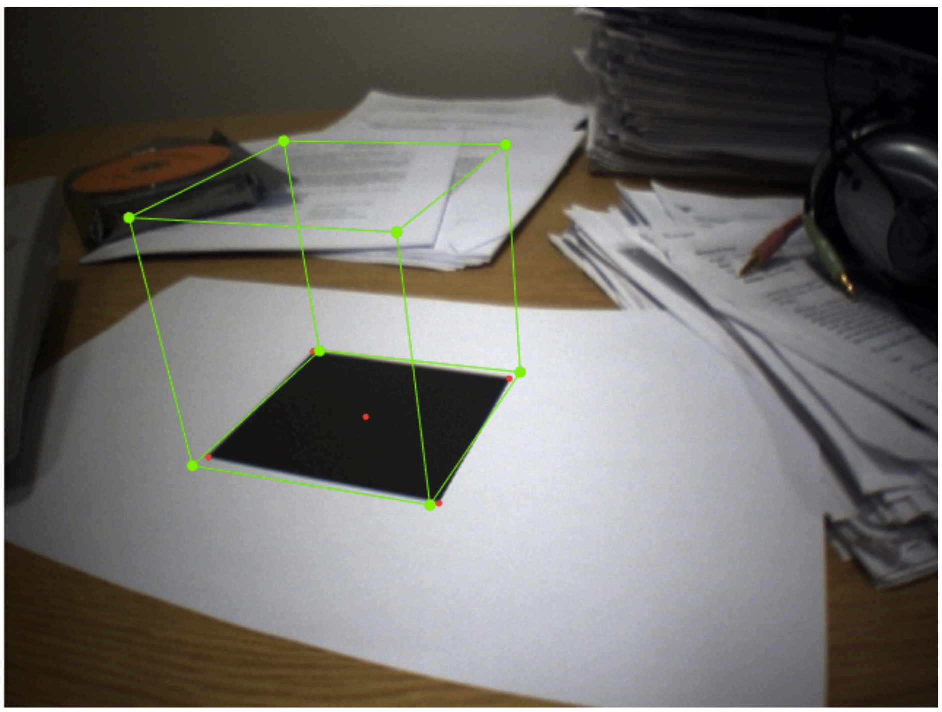

figure 4-1

In figure 4-1, the red points are five points of the black square in the image, and they are the true position of this black square in the image. After estimating the extrinsic matrix TEst, given 8 3D points of the corner of a cube in the world, the green points are the estimated positions of these 8 corners of the cube in the image and the green cube is the estimated cube in the image.

E) 09_PracticalCondensation\ Practical9a.m

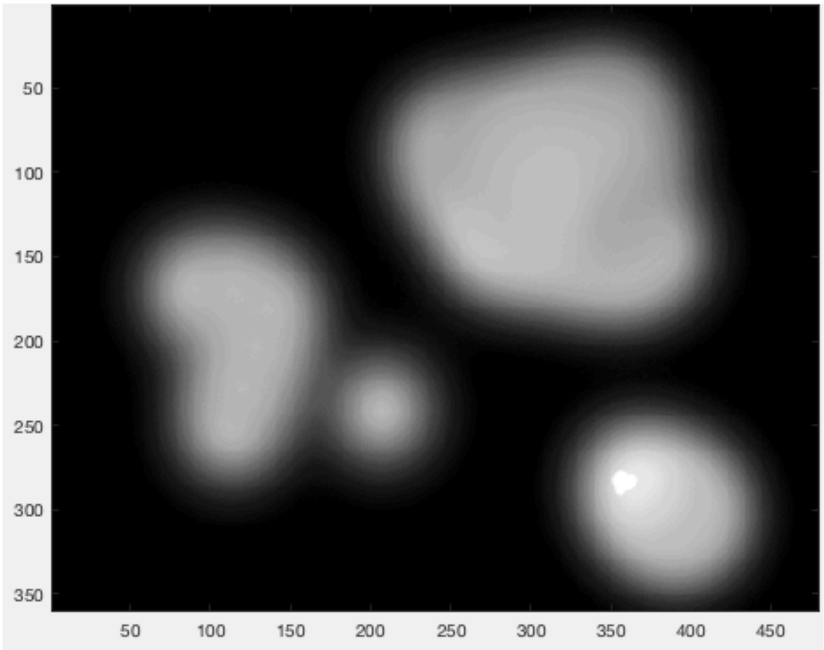

figure 5-1

Figure 5-1 is the gray graph of the original image, and the area whose color is brighter, the probability of this area is larger.

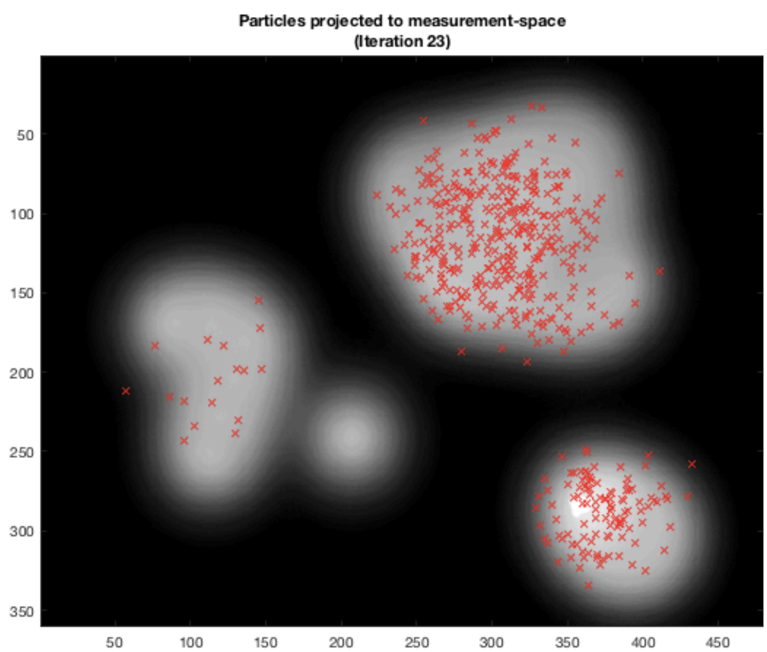

figure 5-2

Figure 5-2 shows the result of factored sampling. The red crosses represent the sampled particles and it can be found that the sampled particles are mainly on the bright areas which are with high probabilities. It is because after the 1st sampling, the particles in these high probability areas are with high weights and easily to be re-sampled.

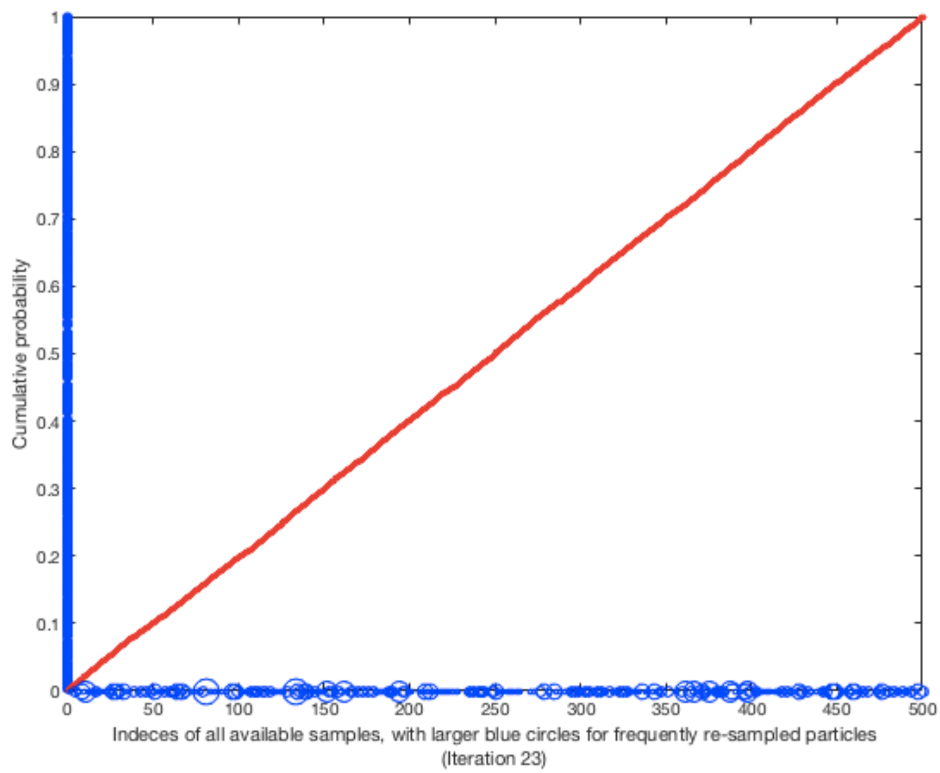

figure 5-3

In figure 5-3, after 23 times iterations, the y axis shows the thresholds which are generated randomly and figure 5-3 shows that these thresholds are generated uniformly between 0 to 1. The x axis shows the index of sampled particles and the size of circles indicates the number of sampling. The red line is cumulative sum of weights of sampled particles and the sampled particles have a relatively uniformly weight.

F) 09_PracticalCondensation\ Practical9b.m

figure 6-1

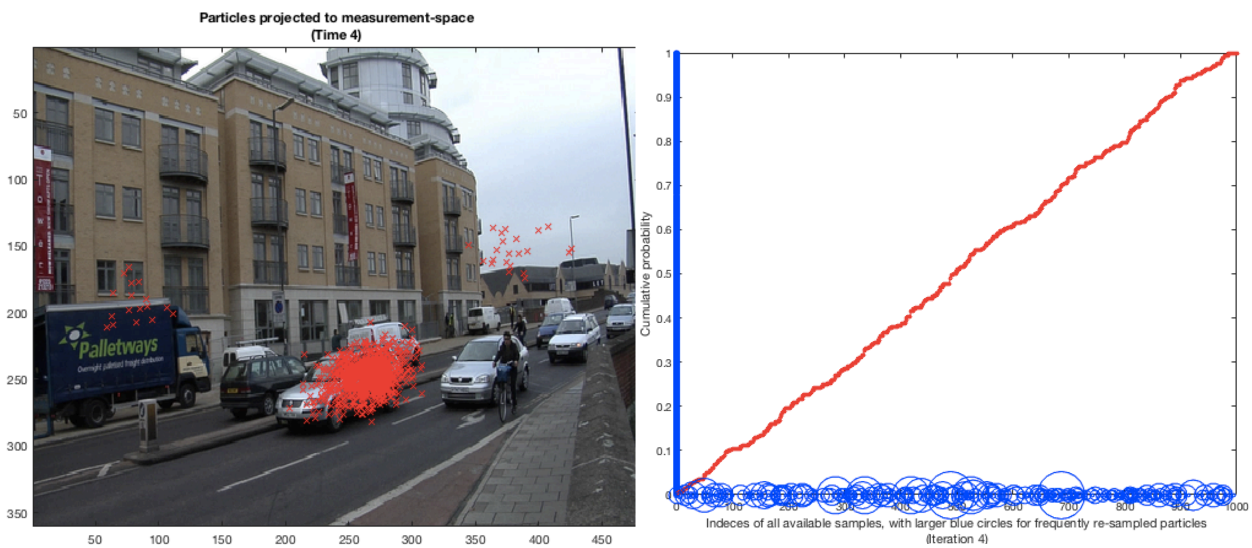

figure 6-2

figure 6-3

The goal of practical 9b is to track a given template in a video and the results (figure 6-1~3) show that Condensation algorithm can effectively track the wheel of the car to some extent. However, one problem is that the particles are mainly on the upper left position of the wheel and it is because the point we use the match the template is the upper left corner of the template and therefore, the points will focus on the upper-left corner of the match positions in the frames rather than the center. Moreover, the move of car towards left and down may be another reason.

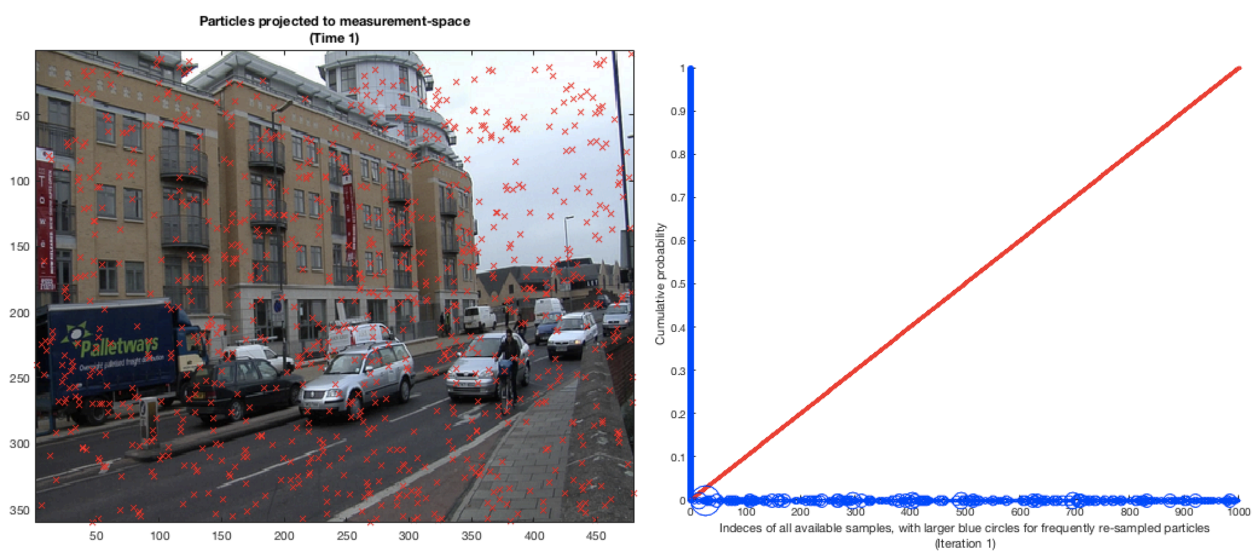

figure 6-4

figure 6-5

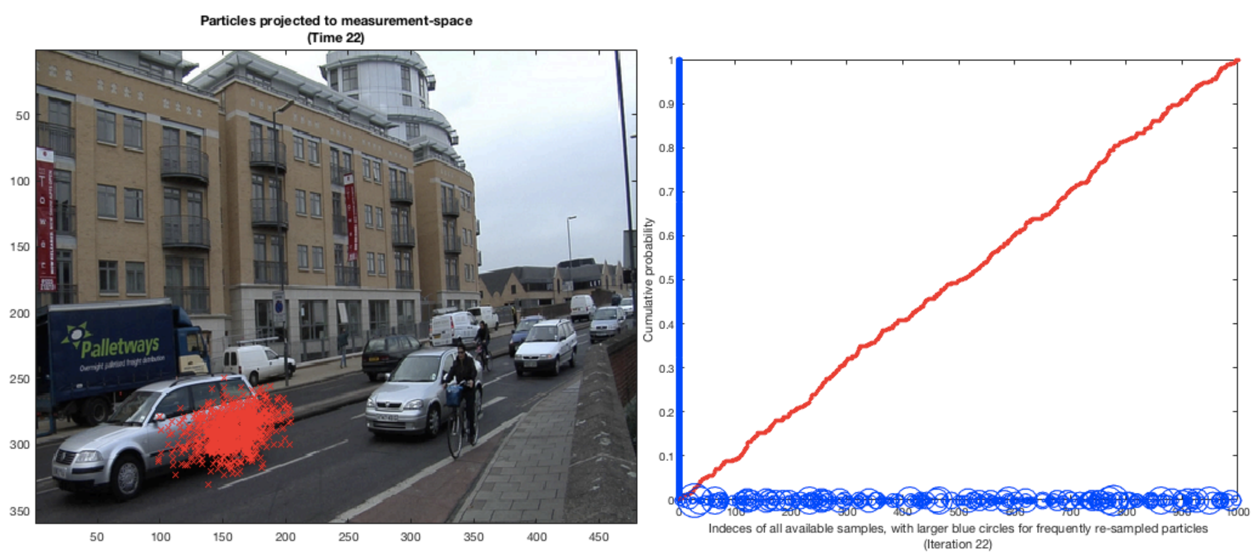

figure 6-6

Figure 6-3~6 show the results after adding two constants: 13 and 9 to the positions of particles compensate for the influence of the position of matching point and the velocity of the car. Condensation algorithm can still effectively track the wheel of the car and the particles are now focus on the wheel.

GH)HW2\HW2_Practical9c.m & HW2\HW2_TrackingAndHomographies.m

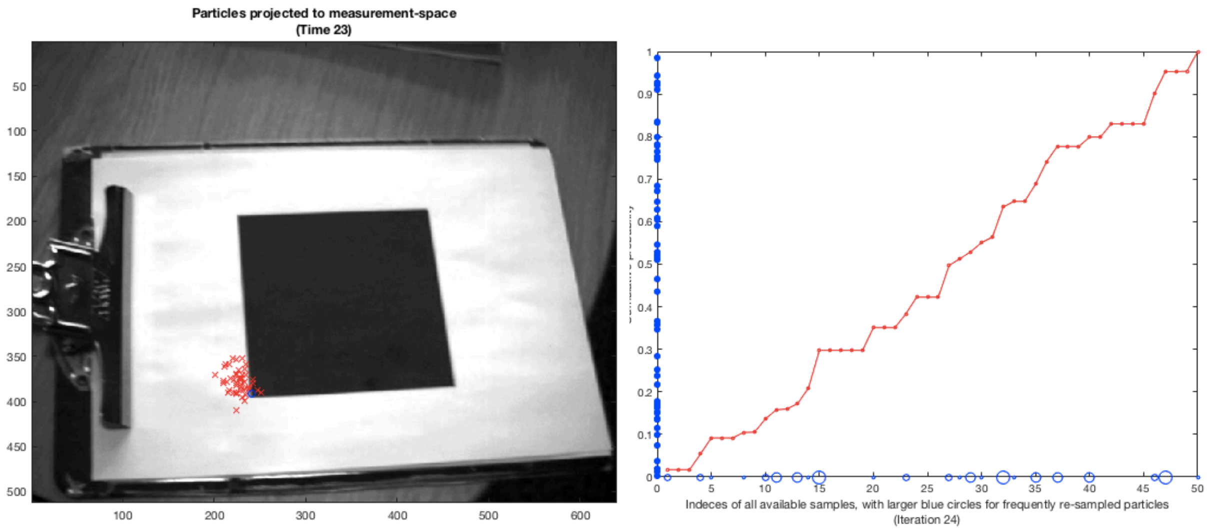

figure 7-1

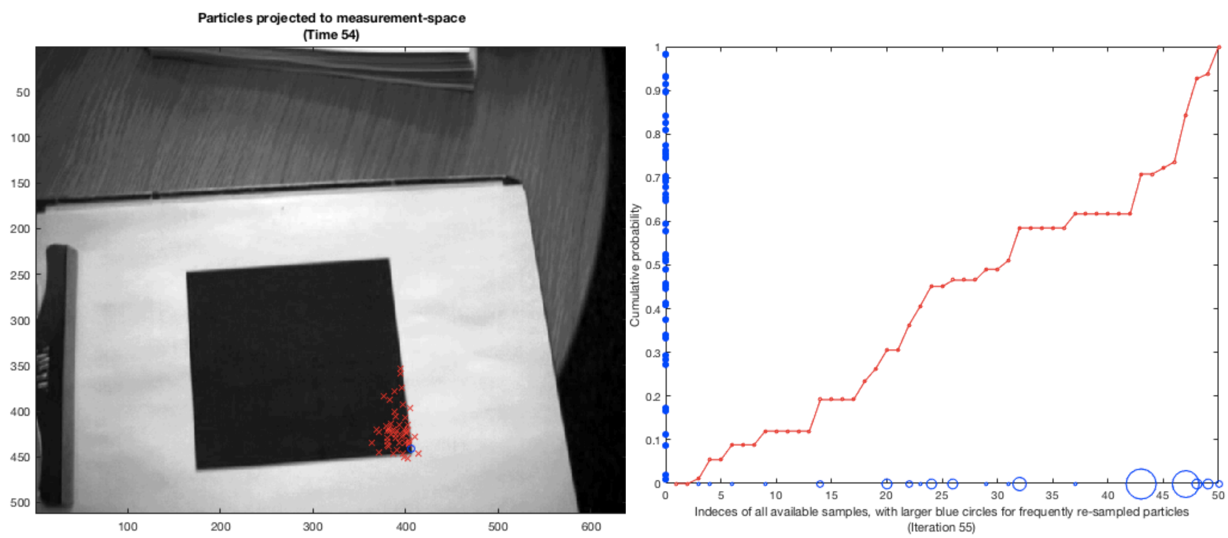

figure 7-2

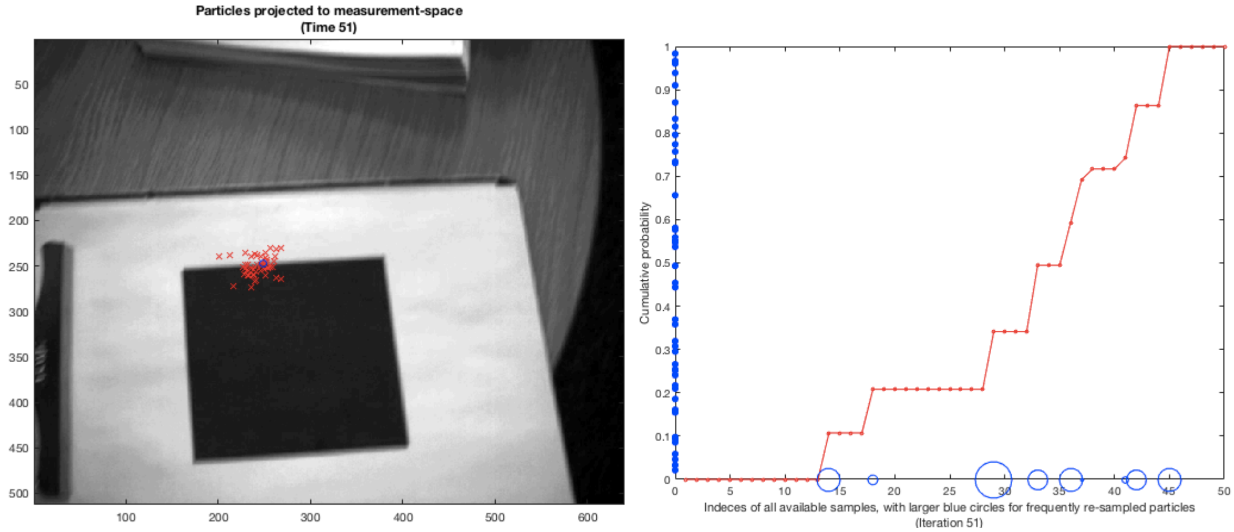

figure 7-3

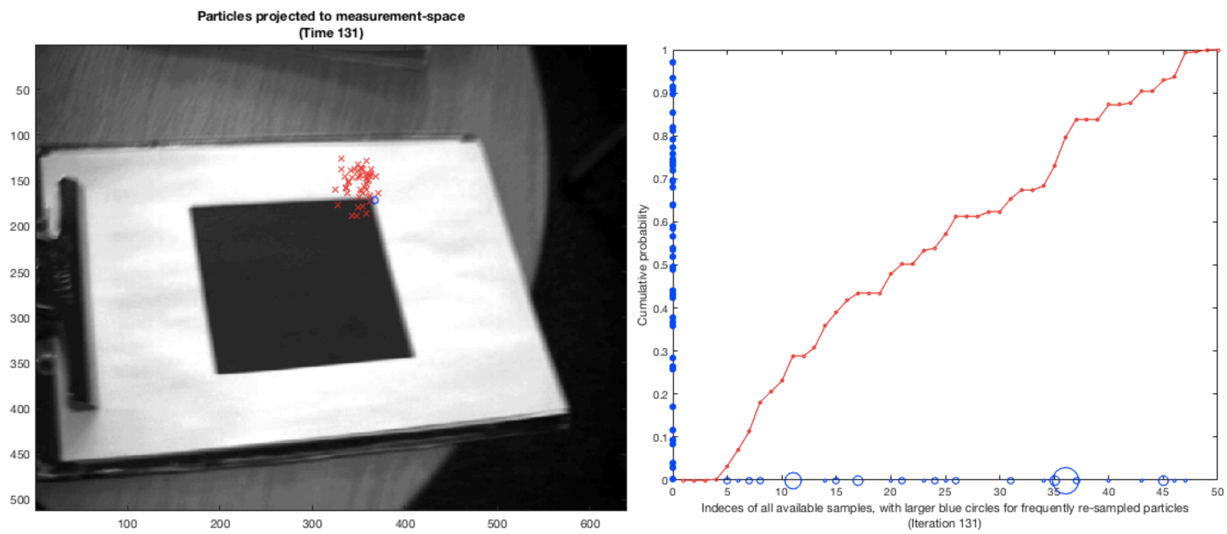

figure 7-4

Figure 7-1~7-4 show the results of practical9c: to detect the four corners of the black square in the video. In most frames of the video, the corners can be detected effectively since red particles are focus around the corners. However, sometimes particles may move to edges far away from the corner (shown in figure 7-3).

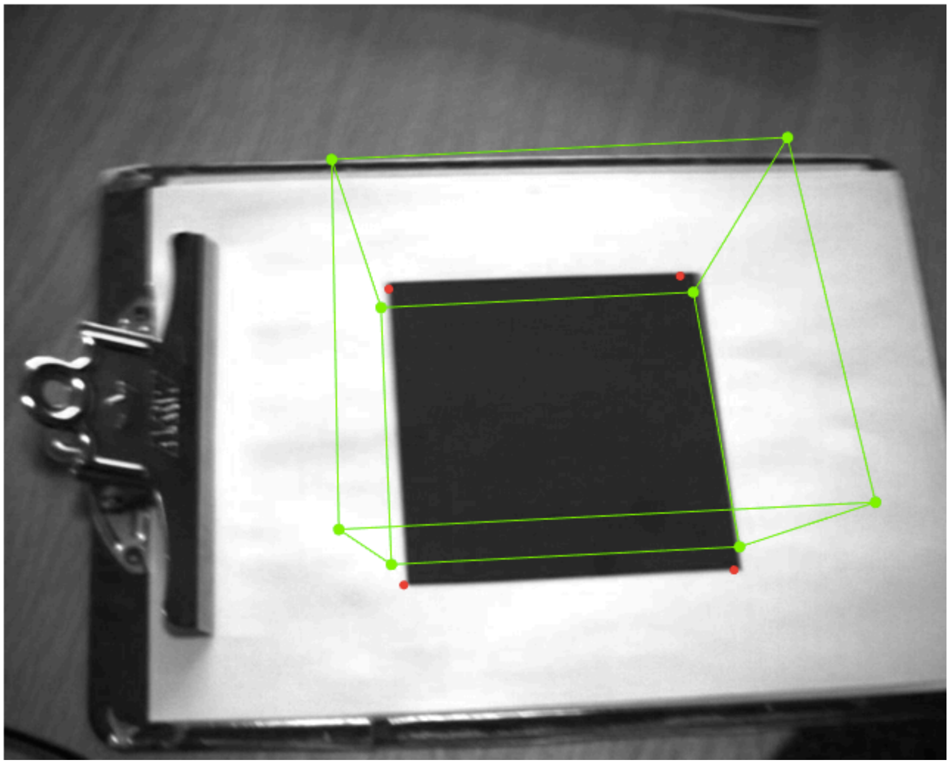

figure 7-5

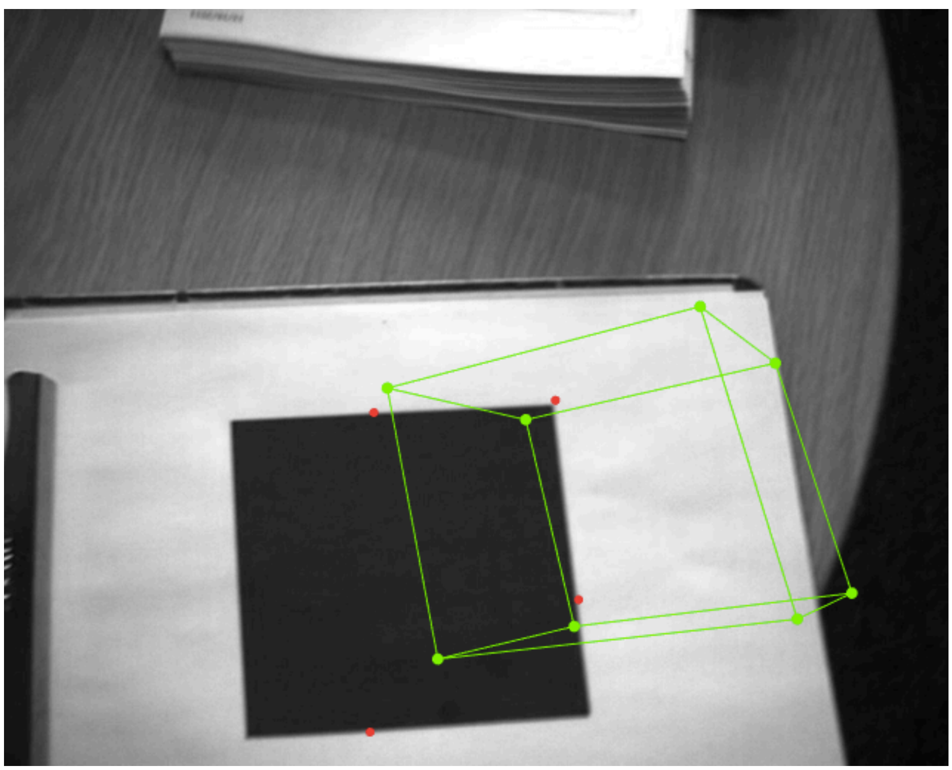

figure 7-6

The red points in figure 7-5~7-6 are the weighted sum of the particles in practical9c, and they are the estimated positions of 4 corners of the black square in every frame of the video and are regarded as the true positions of the black square in the Homography process. The green cube is the estimated cube in the video from the relation between the position of 4 corners of the cube in the world and the real position of these 4 corners in the video. In some frames of the video, the cube can be effectively estimated to some extent (figure 7-5), but in some frames (figure 7-6) the cube is greatly off the black square.

TO DO
The results are not stable and unrealistic because in tracking process in some frames the edges are detected as corner. Moreover, in some frames, the black square move greatly so that the Condensation algorithm cannot track the corners effectively. Increasing the number of particles in tracking process, corner detection and detecting edges can be effective ways to improve the results.

Edge-detector

Firstly, adding an edge detector using prewitt filter (edgedetector.m) to find out the pixels in the edges (figure 8-3-1). Secondly, using these edge pixels to filter particles: if a particle is not on the edge, then the weight of this particle multiply ½ (practical9candedgedetector.m) to decrease the probability of particle lying on the non-edge area.

Results are shown as following (figure 8-1~8-3). After adding an edge detector, the estimated points (blue o points) are more focus around the corners, increasing the accuracy of estimation. However, edge detector cannot solve the problem: in some frames, the particles lie on the edges rather than the corners (figure 8-4).

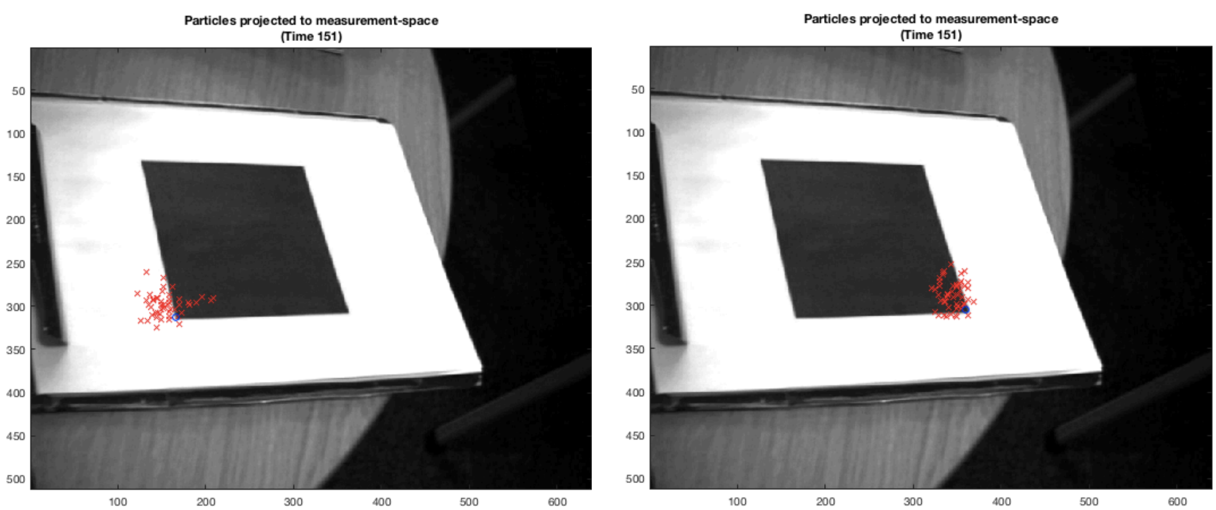

figure 8-1

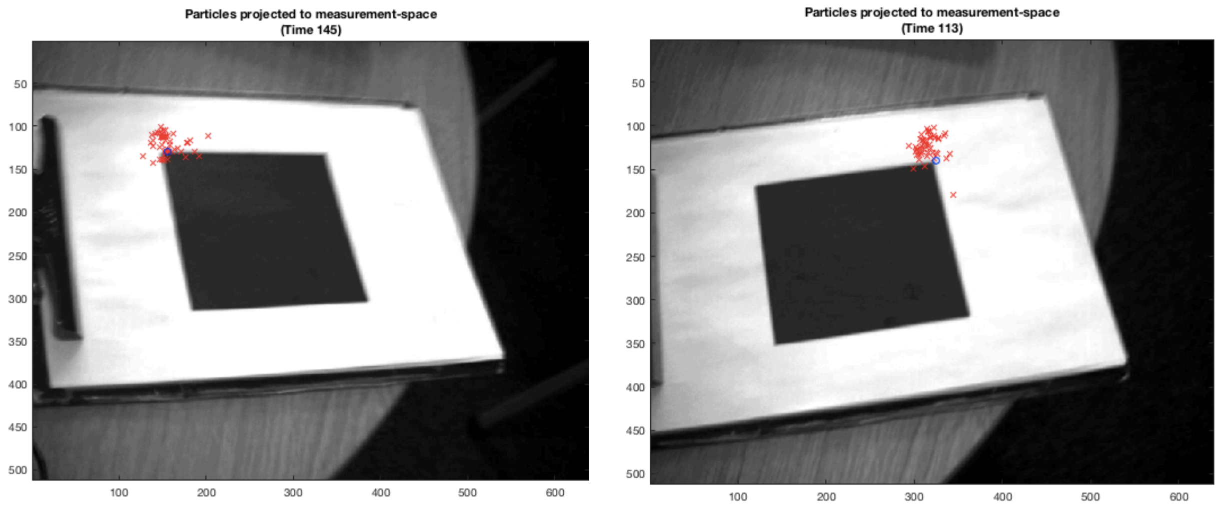

figure 8-2

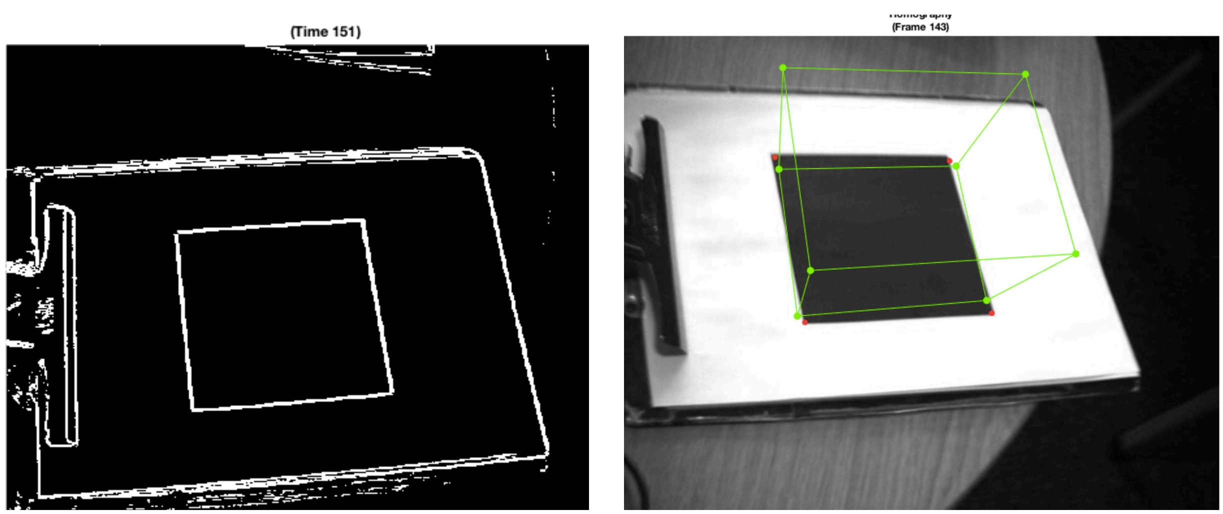

figure 8-3

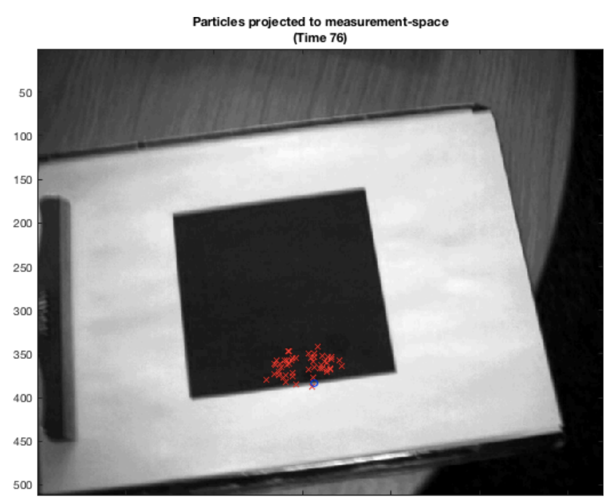

figure 8-4

Using a different video (file: HW2-2 & pattern02)

Firstly, recording a video and transforming into images and data (LoadVideoFrames2.m) and then creating the template (createtemplate.m). Secondly, using the Condensation algorithm (candedgedetector2.m) to track and estimate the positions of four corners and results are shown as following. The homography part remains to be done(trackingandhomographytriangle.m).

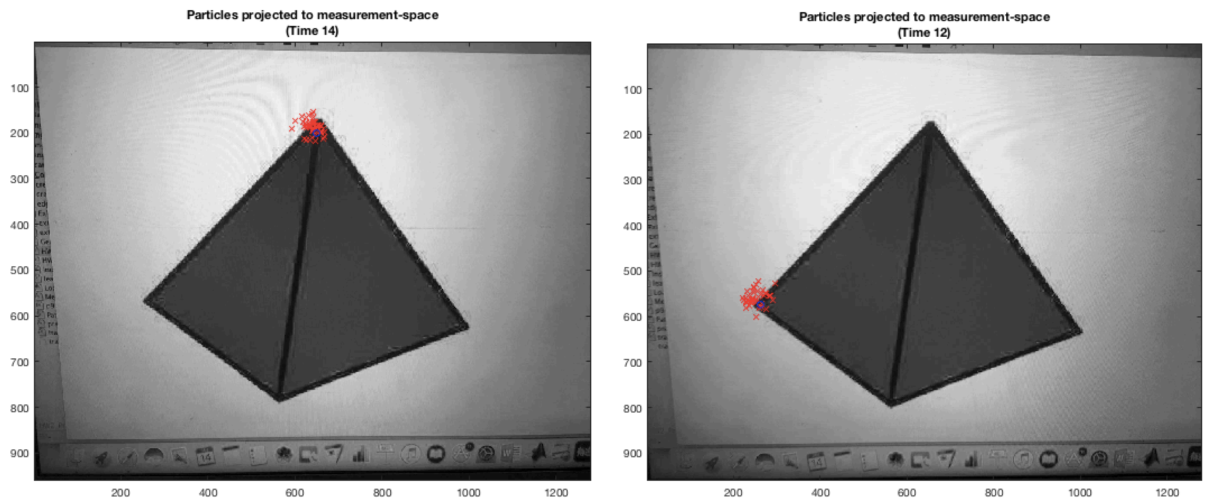

figure 9-1

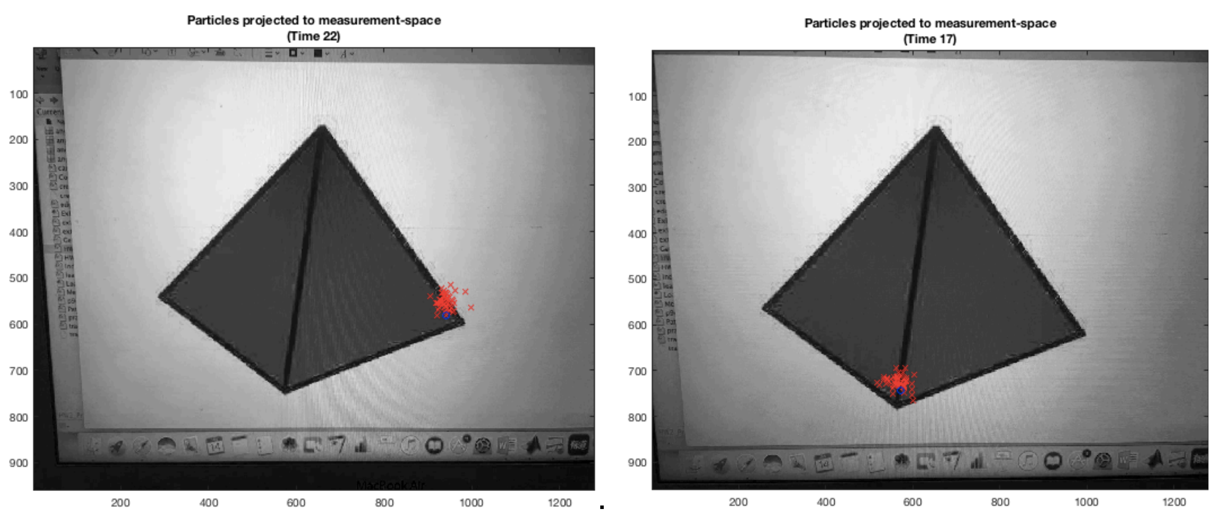

figure 9-2