Computer Vision Lab 6 Report

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1. DERIVE MATRIX A

To derive Matrix A, we need to consider two scenarios: (a) no motion at all; (2) constant velocity model.

For scenario (a):

$$A = \begin{bmatrix} 1 & 0 \\ 0 & 1 \end{bmatrix} \tag{1}$$

$$\underset{2\times k}{p'} = \underset{2\times 2}{A}{}_{2\times k} + \begin{bmatrix} \Delta x & \Delta y \end{bmatrix}^T \tag{2}$$

For scenario (b):

$$A = \begin{bmatrix} 1 & 0 & 1 & 0 \\ 0 & 1 & 0 & 1 \\ 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix} \tag{3}$$

$$\underset{4\times k}{p'} = \underset{4\times 4}{A} \times k \underset{4\times k}{p} + \begin{bmatrix} \Delta x & \Delta y & \Delta \dot{x} & \Delta \dot{y} \end{bmatrix}^T \tag{4}$$

2. EXPERIMENTS

2.1 Video 1: Pure Hand

Figure 1 shows the result for video 1. The parameter (Table 1) I am using here is selected by visual quality of tracking. At first, a-posterior results follow a-prior at the hand palm. In the following frames, when the wrist comes into the frame, the tracking becomes to follow the wrist. It makes sense because the color histogram of wrist and hand palm are very similar.

Table 1: Parameters used in video 1.

hist_bin	*alpha*	*model*	$\sigma_{observe}$	$\sigma_{position}$	$\sigma_{velocity}$	*num_particles*	*initial_velocity*
16	0.7	1	0.1	15	1	300	(1,10)

2.2 Video 2: Hand with Backgrounds

Parameters that support visually good result are shown in Table 2. The plot is shown in Figure 2.

Table 2: Parameters used in video 2.

hist_bin	*alpha*	*model*	$\sigma_{observe}$	$\sigma_{position}$	$\sigma_{velocity}$	*num_particles*	*initial_velocity*
16	0.7	1	0.1	15	1	300	(1,10)

2.2.1 The effect of constant motion model

We can't find large different between whether adding constant motion model or not in most cases. But since there is randomness when adding systematic errors and observation errors, sometimes, we can find the tracking of constant-motion model cannot track well when the hand disappear with an accelerated speed. The results are shown in Figure 3.

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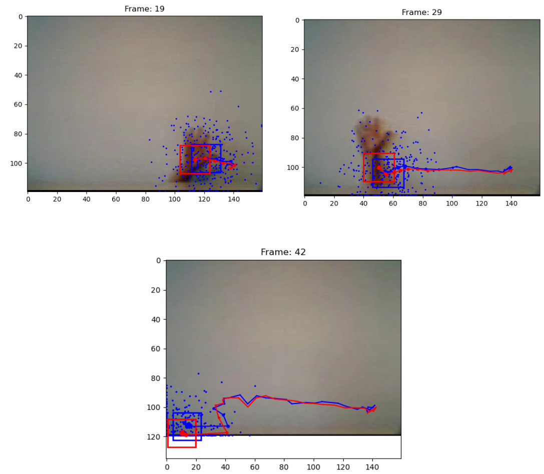


Figure 1: The tracking results for video 1.

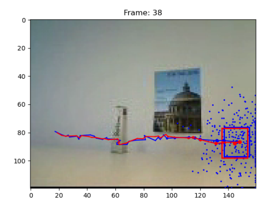
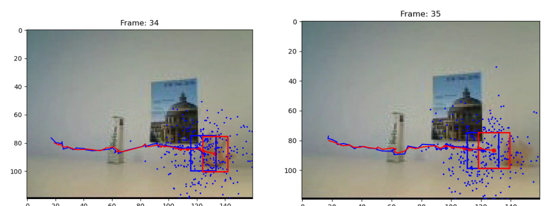


Figure 2: The tracking results for video 2. The parameters are in Table 2.



(a) No motion (b) Constant velocity

Figure 3: The tracking results for video 2. The other parameters are keep the same as shown in Table 2.

2.2.2 The effect of decreased/increased system noise

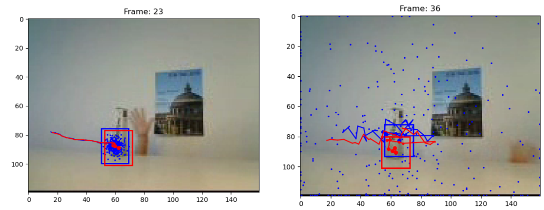
The very small system noise (i.e., $\sigma_{position}$ and $\sigma_{observation}$) causes losing tracking target when the target passes through some obstacles. Because the small noise makes the variance of particles small, then the weighted mean state cannot go through through the obstacle. While the extreme large system noise causes losing of track either. It mainly due to the large variance of particles - particles sparsely cover the whole image. Then the color histogram around particles and the calculated mean state cannot give enough weight to the tracking target region, thus it cannot track very well. The results are shown in Figure 4.

2.2.3 The effect of decreased/increased observation noise

Similar to system noise, very small observation noise cannot support tracking when the target occludes behind some obstacles due to its small variance of particles. Very large noise may also lose tracking due to its very large range of particles which cover the whole image frame.

2.3 Video 3: Ball

I used the same parameters as shown in Table 2. It successfully tracks the ball as shown in Figure 5.



(a) $\sigma_{position} = 3$ (b) $\sigma_{position} = 50$

Figure 4: The tracking results for video 2 with different system noise. The other parameters are keep the same as shown in Table 2.

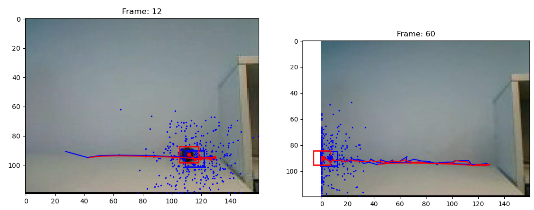


Figure 5: The tracking results for video 3.

Large noise makes the variance of particles too large - covering the whole image frame. It may lose tracking due to the problem. On the other side, very small noise makes the variance of particles very small. However, it usually does not impact the quality of tracking since the ball is very compact and a very small area of particles could accomplish the tracking task. The motion effect is similar to hand tracking in video 2.

3. DISCUSSION

The number of particles may impact the result. Very small number of particles (i.e. 10) loses the tracking due to its very small range of covered area. Large number of particles make the tracking trajectory smoother, and slow down the computation.

Very small bin numbers may lose tracking since we cannot distinguish different targets by color histogram if the bin resolution is too low.

Very small α (i.e., 0.001) means we preserve the original color histogram, while large values means we update most of the current color histogram. We found low alpha may lose tracking when passing through some obstacles.