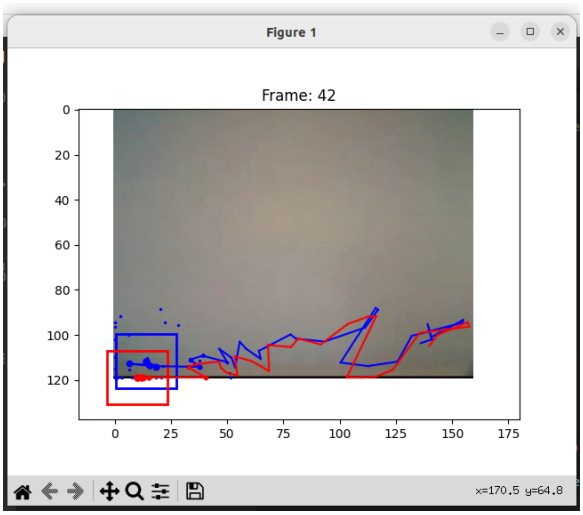
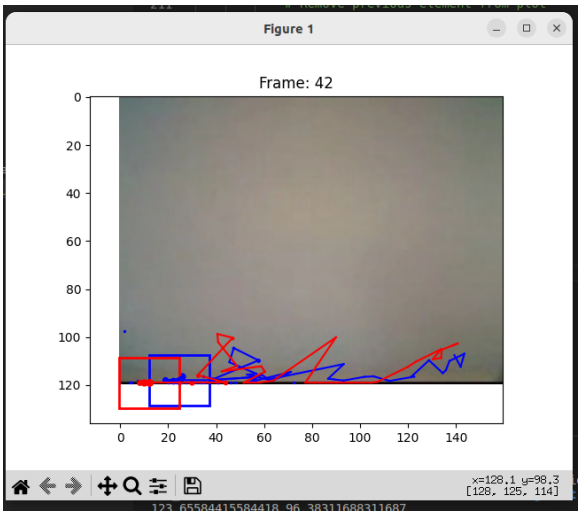
CV lab 6 tracking
Algorithm:

2.Matrix A: assume the state have d dimension then matrix have shape d*d. If the model assumes no motion then d=2 and A is simply the identity matrix. If model assume constant velocity then d=4 and since velocity should be fixed then A[2,:] = [0,0,1,0] and A[3,:] = [0,0,0,1]. The x and y coordinate should also be updated by the speed*time elapsed between the 2 frames, here i assume time =1 so A[0,:] = [1,0,1,0] and A[1,:] = [0,1,0,1]

Experiments:

1. Tracking of video 1



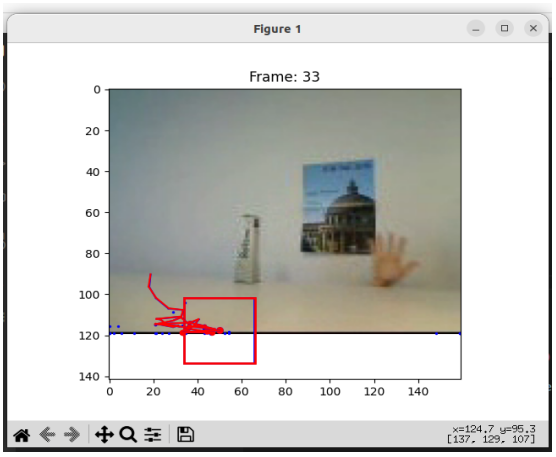


Tracking using the default hyperparameter tracking using model 1

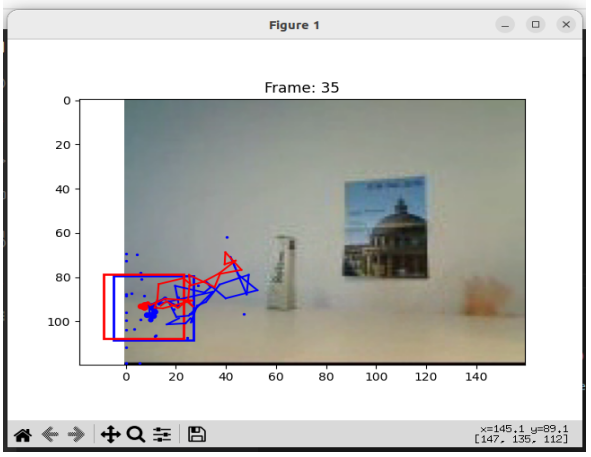
Surprisingly a model that assumes no motion seems to be performing better than the model that assumes linear velocity. This can caused by the fact that the hand movement direction changed over the video s course and thus making the linear velocity assumption invalid.

2. Tracking of video 2

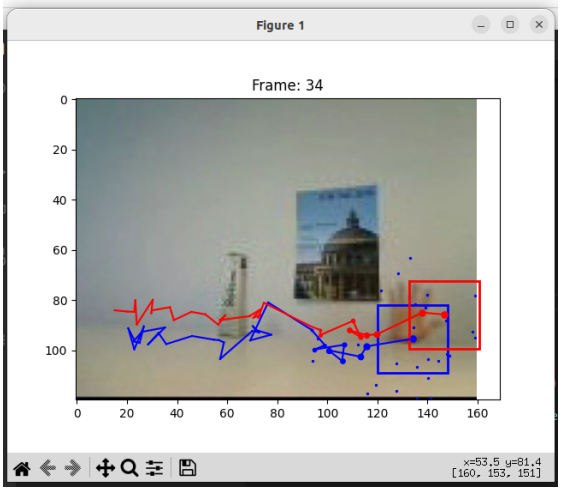
Effect of changing sigma_observe:
A large sigma_observe value give more weight for particules that have a small X2 value that doesn't match the reference histogram as well as the ones that matches the color histogram. Consequently we see that the model fails to follow the hand with sigma_observe = 1 or 10. A sigma_observe<1 on the other hand is more greedy in its evaluation: it only values the particles that have good matching with the reference color histogram. Which makes the posterior (red line) further away from the prior estimation of the mean prediction(blue line).



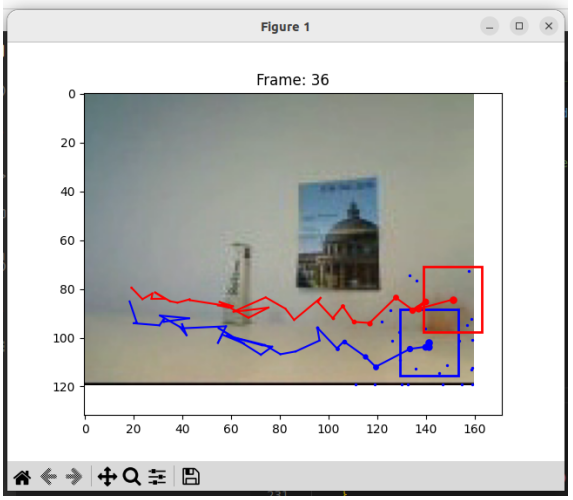
Video 2, sigma observe =10



Video 2 sigma observe = 1

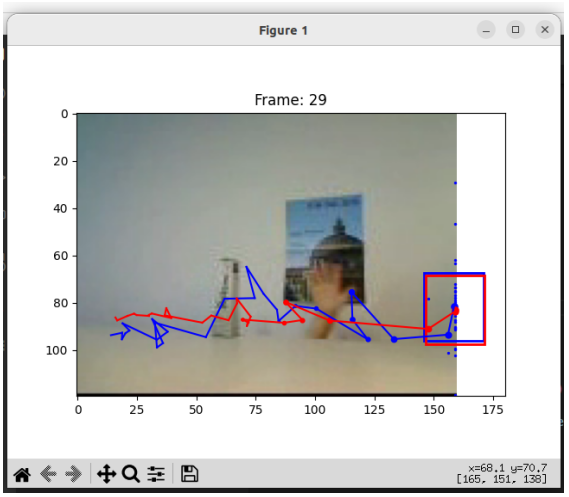


V2 default

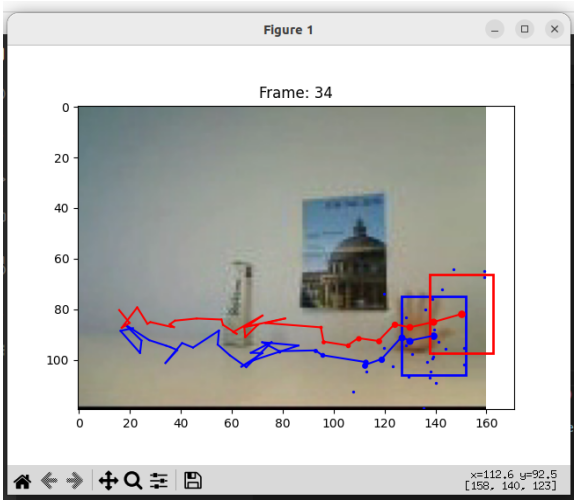


V2 sig ob =0.05

Effect of changing sigma velocity:
A large sigma velocity makes the model less stable and prune to over estimate the change in speed, as show in the figure to the left below, whereas as a small sigma velocity might not be able to accommodate the change in speed if the object start to change velocity or direction.



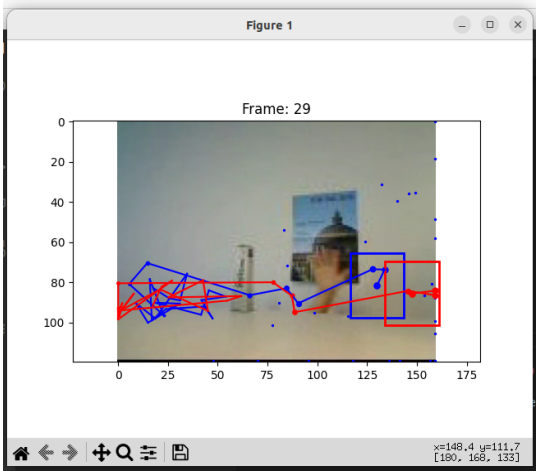
V2 sig v =5



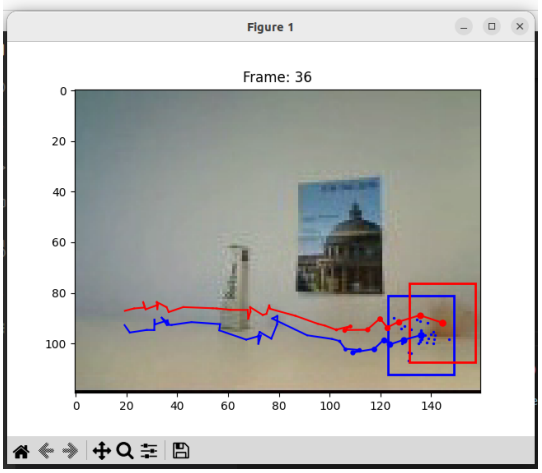
V2 sig v =0.1

Effect of changing sigma location:

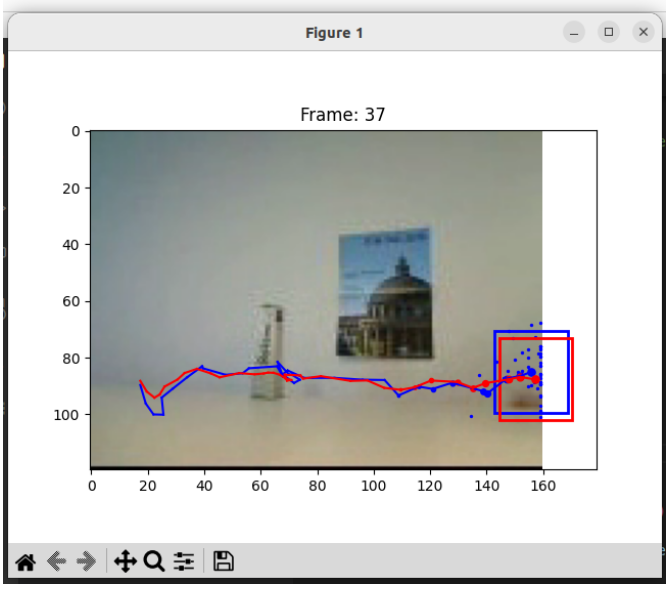
A large sigma location makes the distribution of the particles more disperse and a small one on the other hand concentrate the particiles. Thus the model can fail to obtain meaningful estimation point and thus lose track of the point if the sigma location is too large(left) or potentially fail to sample the object if object location change abruptly when the sigma is too small.



V2 sig loc = 50



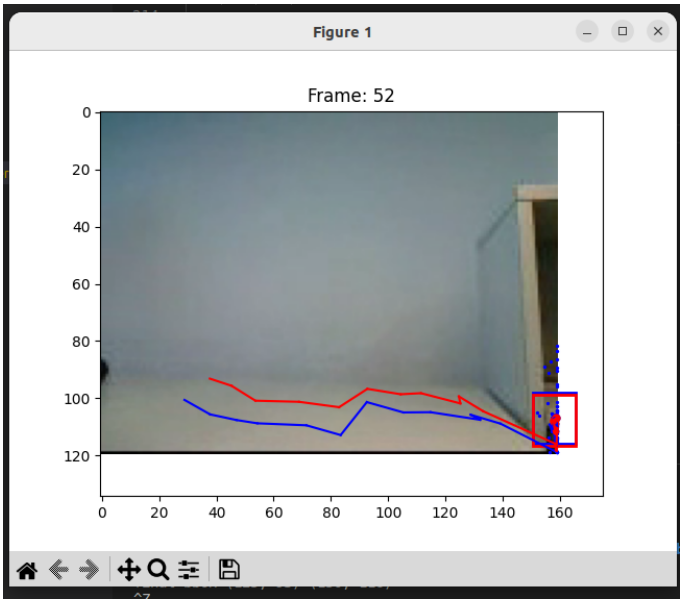
V2 sig loc = 5



Tracking with best hyperparameters.

```
"alpha": 0,
"sigma_observe": 0.5,
"model": 1,
"num_particles": 50,
"sigma_position": 5,
"sigma_velocity": 2,
"initial_velocity": (1, 10)
```

3. Tracking of video 3



Using the same hyperparameter as used in the previous task, the model is not able to track the model once it bounce back. the reason can be multi fold: 1. The previous

hyperparameter reduce the standard deviation in positional noise, which means when the ball bounce away, the distribution of the particles is not disperse enough to cover the new location of the ball. 2. Our Linear tracking model expect the ball to continue moving right when the bouncing happened, which makes the particles sampled at the next iteration far away from the actual location of the ball. 3. The bottom right corner of the picture have a black region that have similar color histogram which can serve as a sub optimal choice for the particles to be stuck on. This video essentially show cased that models can oversimplify complicated scenario and noise / semantics and prior knowledge are needed to account for special cases to enable the model to resuming tracking when unexpected event happens.

4. Hand in
   What is the effect of using more or fewer particles?
   More particles reduce the noise in the stochastic update , making the trajectory smoother and less likely to suffer from outlier.

   What is the effect of using more or fewer bins in the histogram color model?
   Using more bins will make the bin count more accurate

   What is the advantage/disadvantage of allowing appearance model updating?
   Allowing the appearance model updating can account for cases where the hand is out of frame or being partially occluded. However an inaccurate posterior estimation of the mean location can also corrupt the quality of the color histogram if we allow the model to update.