Computer Vision
ETH Zürich
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Lab Assignment 9 - Condensation Tracker

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1 CONDENSATION Tracker Based on CH

1.1 Color histograms

In this part, I extracted the image delimited by the boundary box and then calculated the histogram for each channel using the `imhist(I, hist_bin)` function. The output of the `color_histogram` is a `hist_bin` by 3 matrix containing one histogram column for each channel.

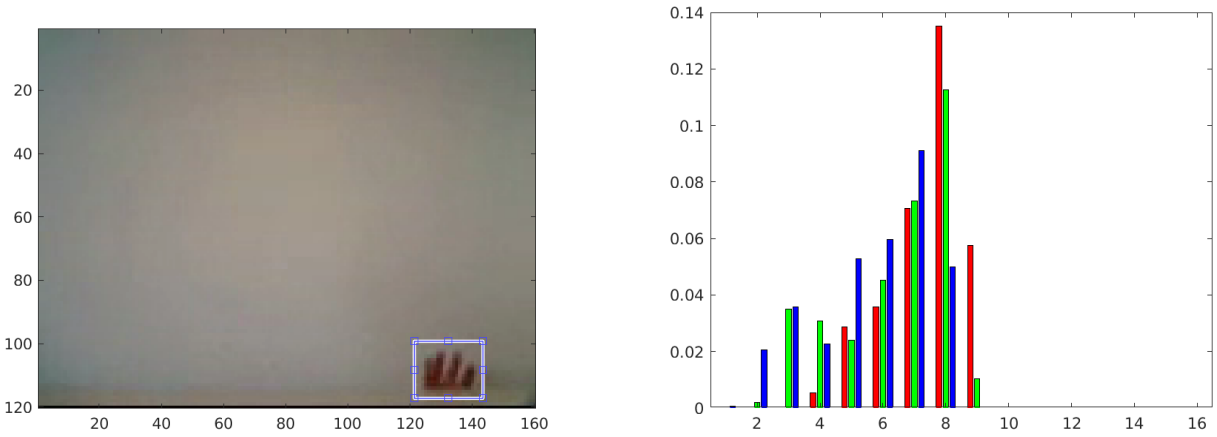

Figure 1: Color histogram of the initial user-selected boundary box.

1.2 Derive matrix A

The matrix A will depend on the model. For the model without motion, only the stochastic part is considered which results in $A_0 = I_2$ and $p' = A_0 p + w = p + w$. For the second model, the velocity of the boundary box is also considered. $v\Delta t = \Delta x$ which results in $x_t = x_{t-1} + v_x \Delta t = x_{t-1} + v_x$ and $y_t = y_{t-1} + v_y \Delta t = y_{t-1} + v_y$. Finally,

$$A_1 = \begin{pmatrix} 1 & 0 & 1 & 0 \\ 0 & 1 & 0 & 1 \\ 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \end{pmatrix}$$

1.3 Propagation

In this part, I started by defining the matrix A depending on the model. Then, the new state was calculated, i.e. $p' = A_0[x, y]^T + w$ and $p' = A_1[x, y, v_x, v_y]^T + w$. Then, if the new boundary box center is outside the frame, the max or min frame dimension are considered.

1.4 Observation

In this part, the color histogram of the new boundary box is calculated and compared to the previous state one using the χ^2 distance. The particle weights are calculated and normalized using the provided formula.

1.5 Estimation

This is simply done by performing an element-wise multiplication between `particles` and `particles_w` then summing over the `num_particles` axis.

1.6 Resampling

In this part, I used the predefined re-sampling function `datasample` to choose N samples with replacement and then reassigned weights to each new sample.

2 Experiments

2.1 video1.wmv

The first video represents a moving hand and a uniform background. We can see that the hand is being tracked with both models but they ended up tracked the bottom part of the arm because of the brightness changes during the video.

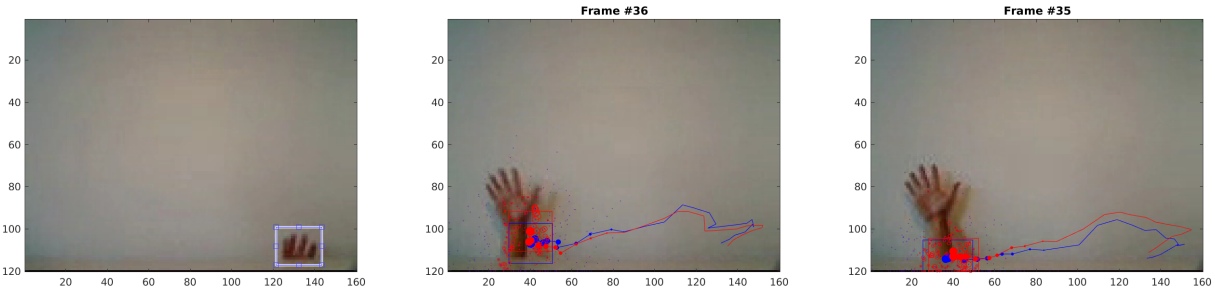

Figure 2: Comparing tracking trajectory of model 1 and 2.

2.2 video2.wmv

In this video, there are some occlusions and the background is no more uniform. Both model were able to track the hand even after including the previous changes (Figure 3. This is due to the relatively high value of the position noise standard deviation. We can clearly see that the model was unable to do the tracking after the occlusions if we reduce the value of σ_{pos} to 1 (figure 4). This same problem can be solved by using the

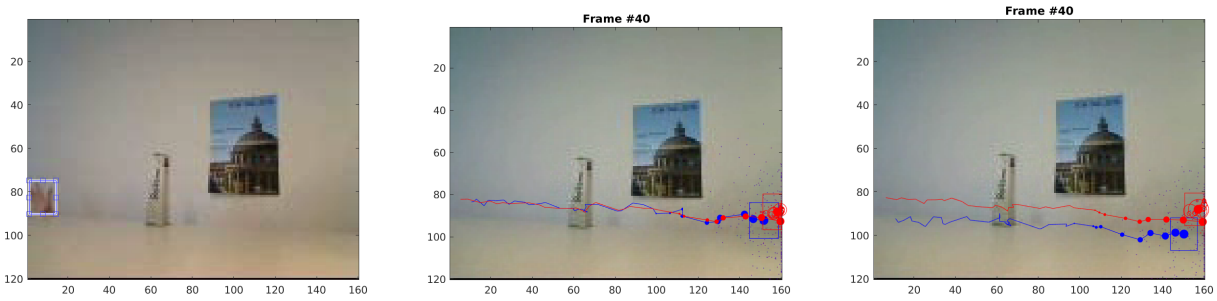

Figure 3: Comparing tracking trajectory of model 1 and 2.

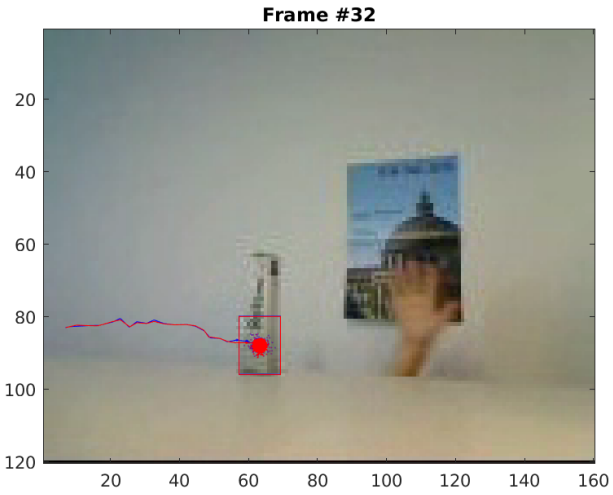

Figure 4: Using a low value of the noise std dev.

constant velocity model and assuming that the initial velocity is only along the x axis, i.e., $v = [1, 0]$. For $v = [1, 10]$, the tracking boundary box is stuck at the beginning (Figure 5).

2.3 video3.wmv

For this video, I started by using the previous parameters: constant velocity model, $v = [1, 0]$ and $\sigma_{pos} = 1$. These parameters are not the optimal ones for this model because the initial ball speed is relatively high (high displacement between frame 1 and 2) which resulted in the boundary box stuck at the beginning (Figure 6). To solve this problem, I used higher velocity along the x axis ($v = [10, 0]$). Another problem is faced using this parameter: after the rebound of the ball, the tracking model continues in the same direction and lost the ball (Figure 7). Finally, I used a higner value of the noise std dev ($\sigma = 10$) as shown in figure 8.

3 Try Your Own Video

I was unable to do this part because I kept getting errors while loading different videos.

```
Error using VideoReader/initReader (line 734)
Could not read file due to an unexpected error. Reason: Unable to
initialize the video properties
Error in audiovideo.internal.IVideoReader (line 136)
```

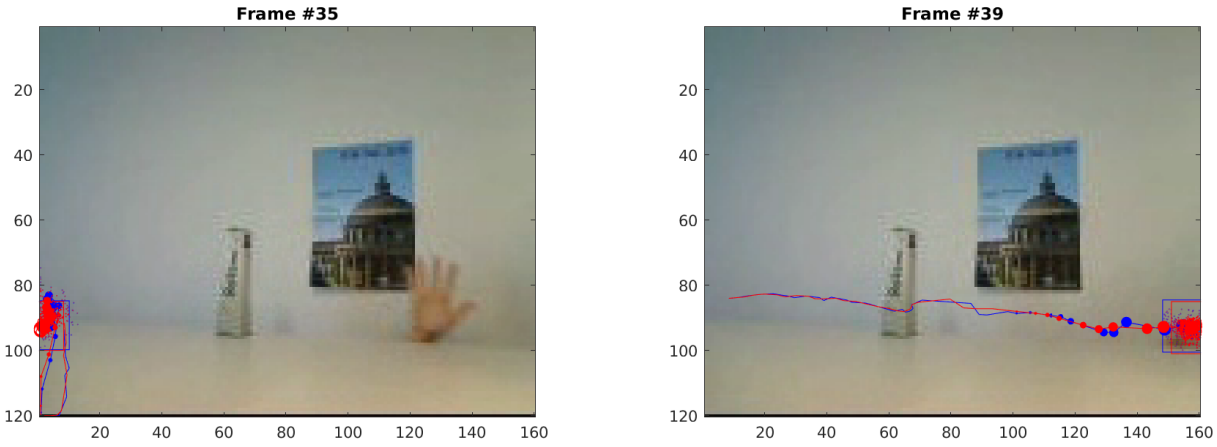

Figure 5: Using different initial velocity vectors ($[1, 10]$ and $[1, 0]$).

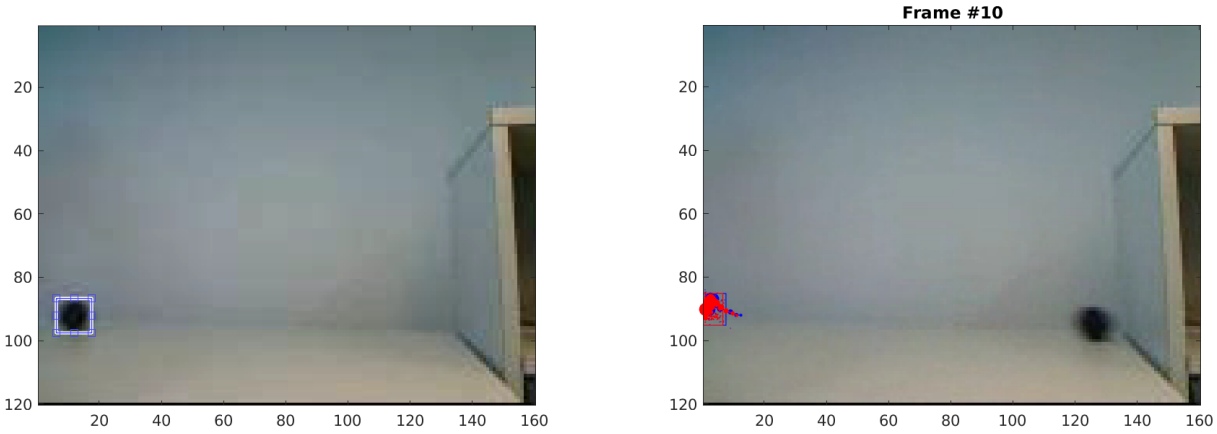

Figure 6: Using previous parameters for video 3.

```
            initReader(obj, fileName, currentTime);
Error in VideoReader (line 104)
            obj@audiovideo.internal.IVideoReader(varargin{:});
Error in condensationTracker (line 61)
    vid=VideoReader(['../data/' videoName '.avi']);
```

I tried some videos available here: `http://www.cvc.uab.es/~bagdanov/master/videos.html`.

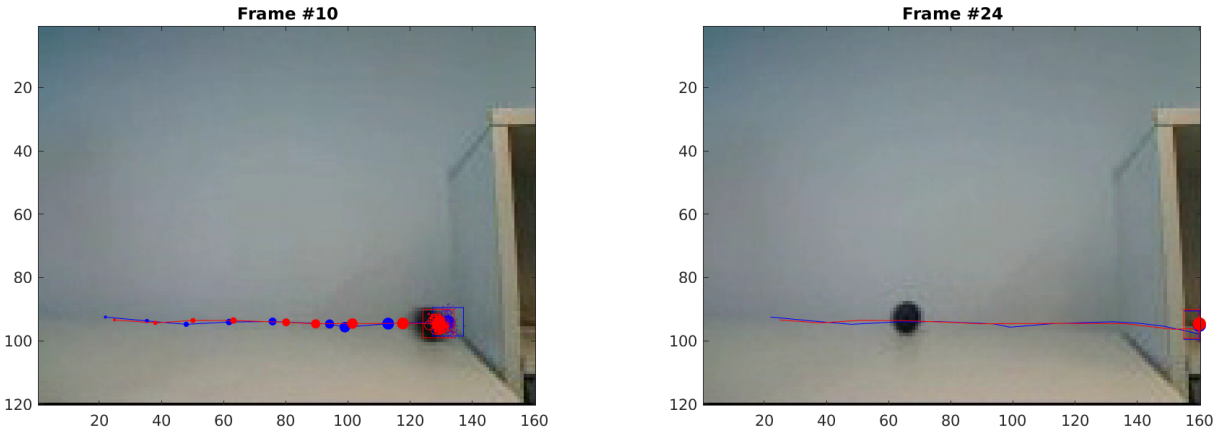

Figure 7: Using $v = [10, 0]$ for video 3.

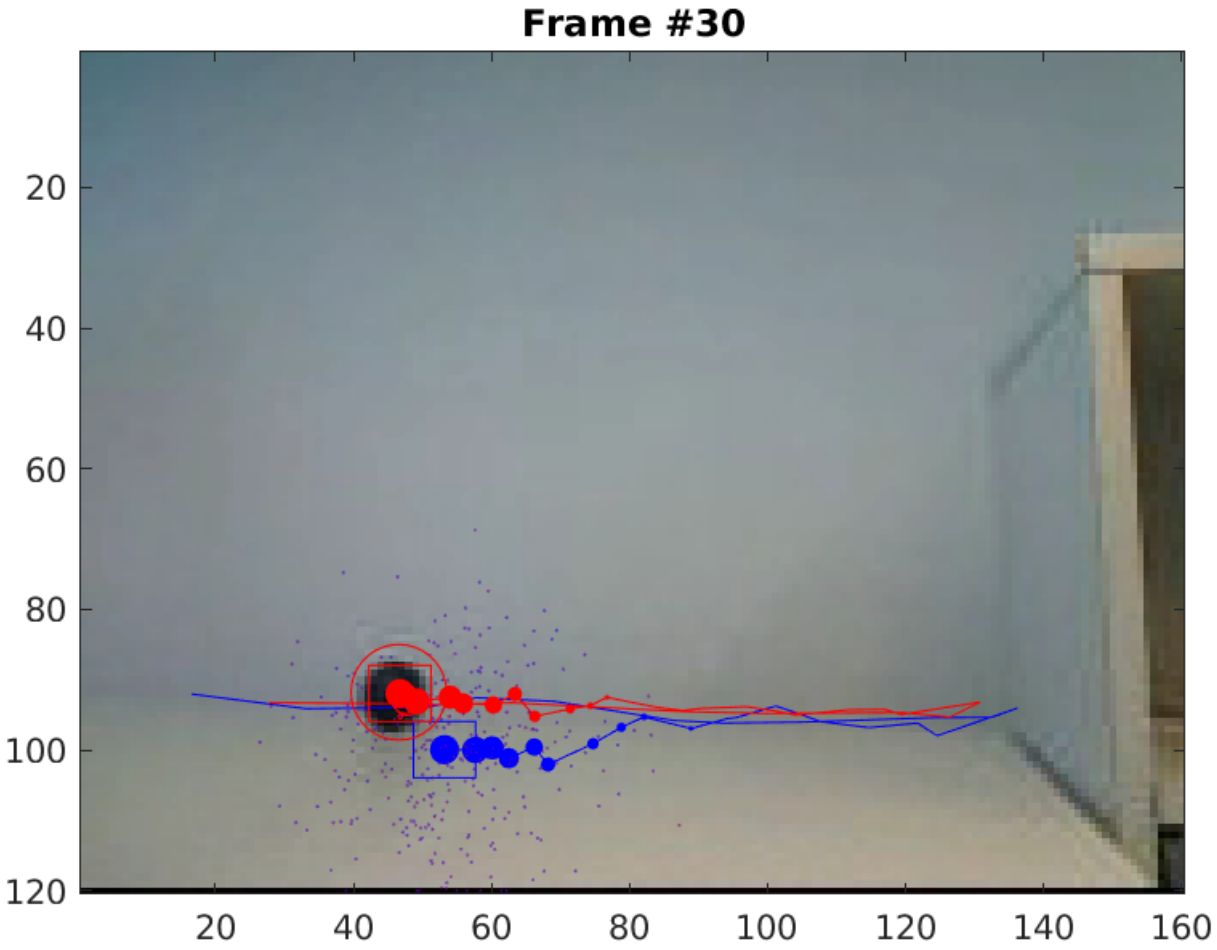

Figure 8: Optimal parameters for video 3.