ASSIGNMENT 7

PARTICLE FILTER TRACKING

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1. Particle Filter Tracking

a. Control group – getting it to work

Figure 1: ps7-1-a-1.png

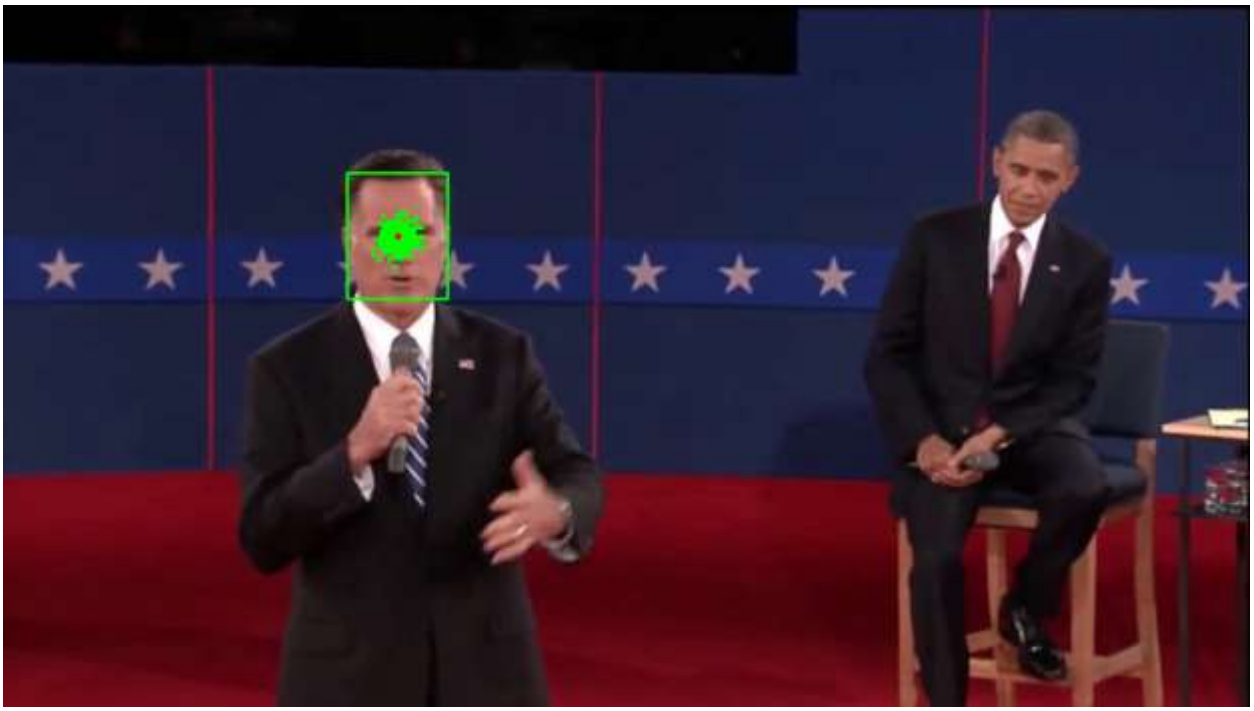

Figure 2: ps7-1-a-2.png Frame 28

Figure 3: ps7-1-a-3.png Frame 84

Figure 4: ps7-1-a-4.png Frame 144

b. Varying window size

Making the window size marginally larger (on the order of 50 pixels) did not seem to have a significant effect. The particle filter was still able to effectively track Romney's head. However, as the window size increased to include more of the background, the filter started tracking the background instead of the head. This makes sense because in the similarity function the template actually has more similarity to the background than to the head.

With a smaller windows size, the behavior was not affected too much. With a smaller window, I couldn't have the template cover the entirety of the face, so I decided to have the template be Romney's forehead. Note: The template contained the hairline, which will come into play later. The particle filter performed well when the forehead was completely visible. However, Romney turns to look behind him, hiding his forehead. When this happened, the tracker locked onto the side of his head near the base of his neck (where the flesh and hairline were most similar to the template). This highlights the shortcoming of a window that is too small – the particle filter can be tricked into tracking something that is similar to the template, but that is not the template.

The best choice for the window size is to that which best captures what you want to track. In this case, we want to track Romney's head, so picking a window size that captures more than just the head or less than the entire head is less than ideal.

c. Adjusting standard deviation

As the σ_{MSE} was increased, the spread of the particles increased and the standard deviation estimate radius increased. As the parameter was decreased, the particles became more clustered. In all the cases I tried, though, the tracker was still able to follow the head.

d. Optimizing number of particles

With as few as 2 particles, I was able to successfully track Romney's head, although the tracking was not quite as good as with more particles. With 5 particles, I was able to obtain results that were comparable to those from using many more particles. With so few particles, the filter ran much faster than with many particles. However, with so few particles, fewer potential states are represented. This means that if the subject being tracked moves unexpectedly, or if there is significant noise, the set of particles could potentially not represent where the subject has moved. Without this information, the tracker will lose the subject, and since there are so few particles in the set, it would be unlikely that any of the particles would find the subject again. Fortunately, unless the sensor and/or dynamics models are complex, it does not take much computational power to process several hundred particles, which is generally all you need to get decent results.

e. Adding noise

I did not find that the parameters needed much tuning with the noise. The tracker was able to work with 50 particles and a σ_{MSE} of 10. I did not even find that I had to adjust the noise for the dynamic model.

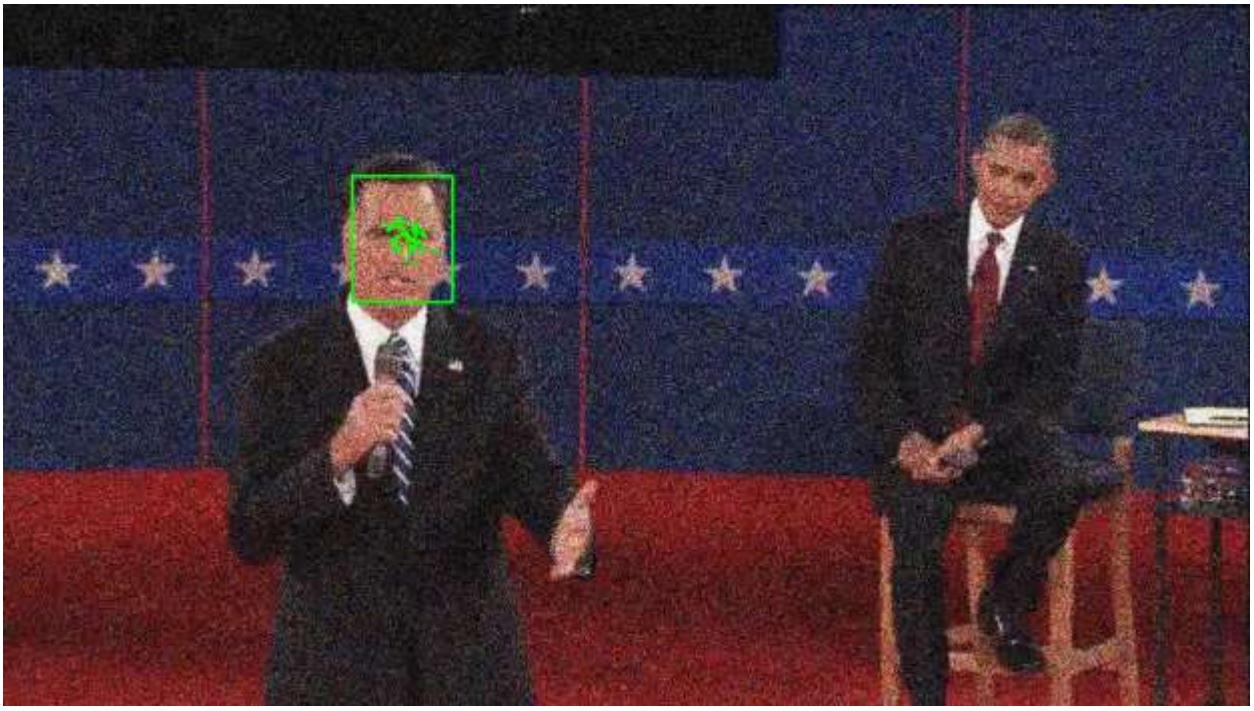

Figure 5: ps7-1-e-1.png Frame 14

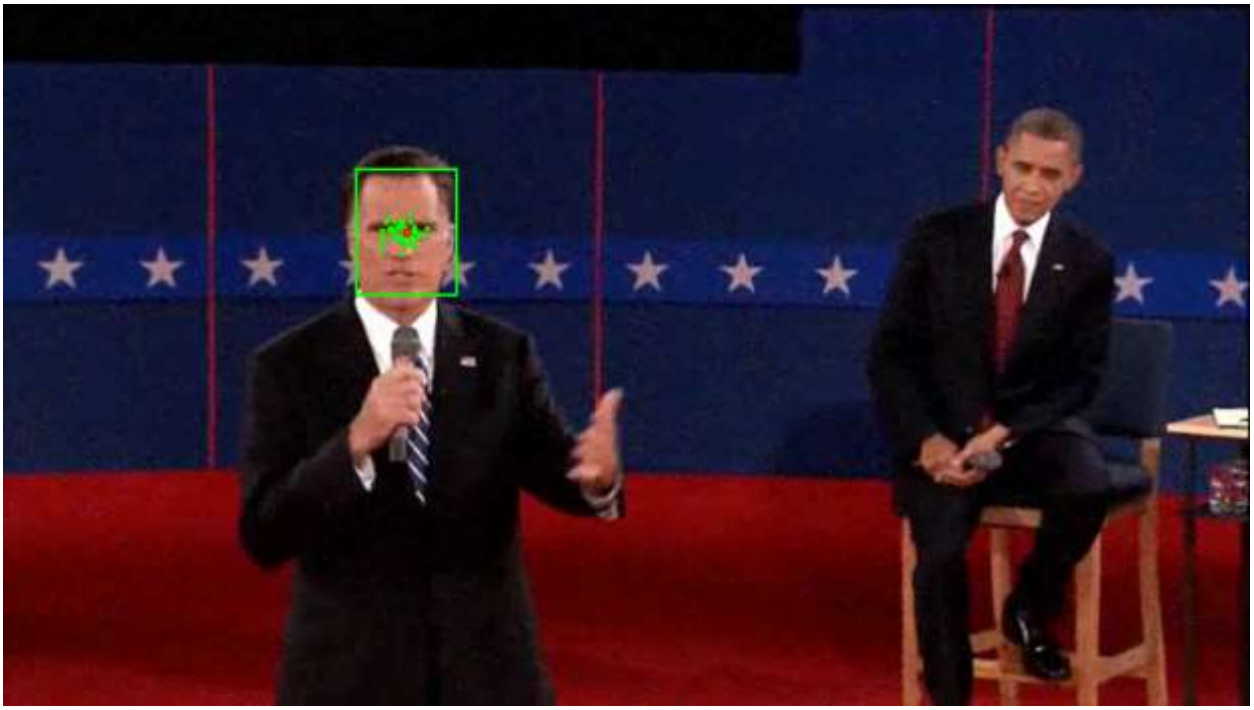

Figure 6: ps7-1-e-2.png Frame 32

Figure 7: ps7-1-e-3.png Frame 46

2. Appearance Model Update

a. Without Noise

Figure 8: ps7-2-a-1.png Hand template

These are the parameters I used for tracking:

$\sigma_{MSE} = 10$

$\sigma_{dyn} = 20$. I had to increase this above the default value to handle the rapid motion of the hand.

$\alpha = 0.5$

number of particles = 300

I did notice that after about frame 160, when the hand turns sideways, the tracker loses it. However, this is beyond the range that we are required to track.

The tracker followed the hand, but it had difficulty staying centered on the hand. I tuned the parameters as best I could, but could not get it to center as well as I would have liked.

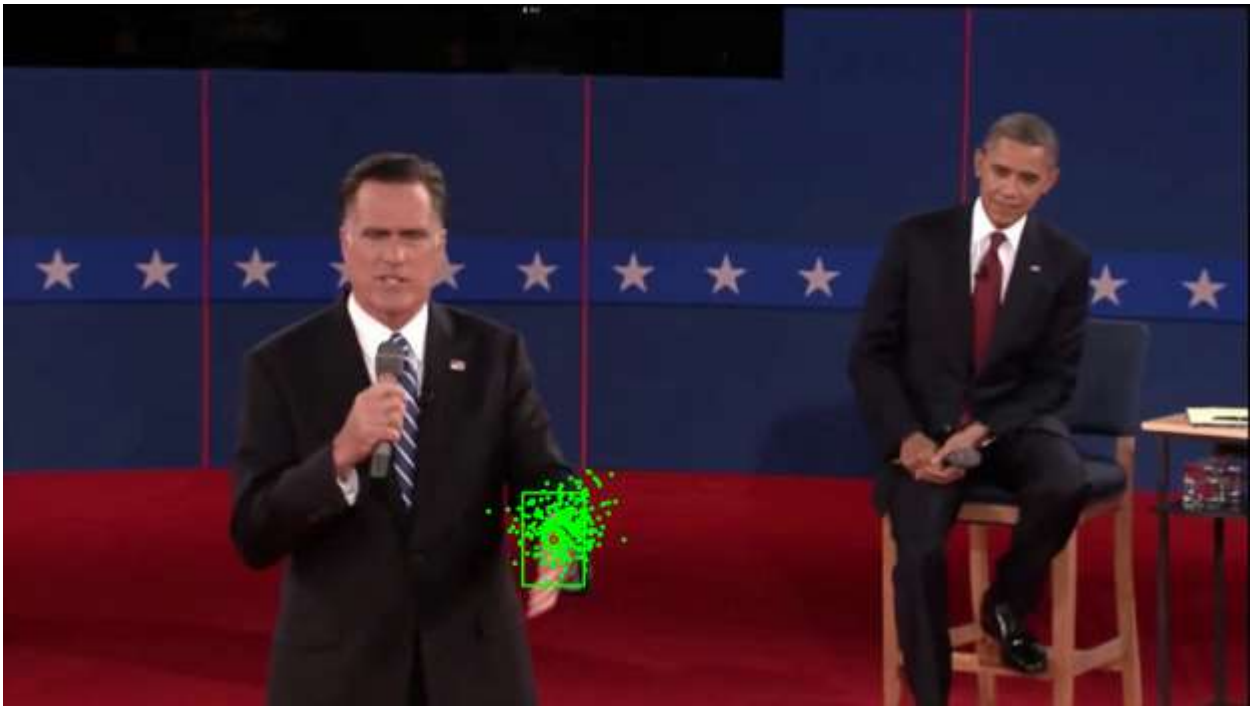

Figure 9: ps7-2-a-2.png Frame 15

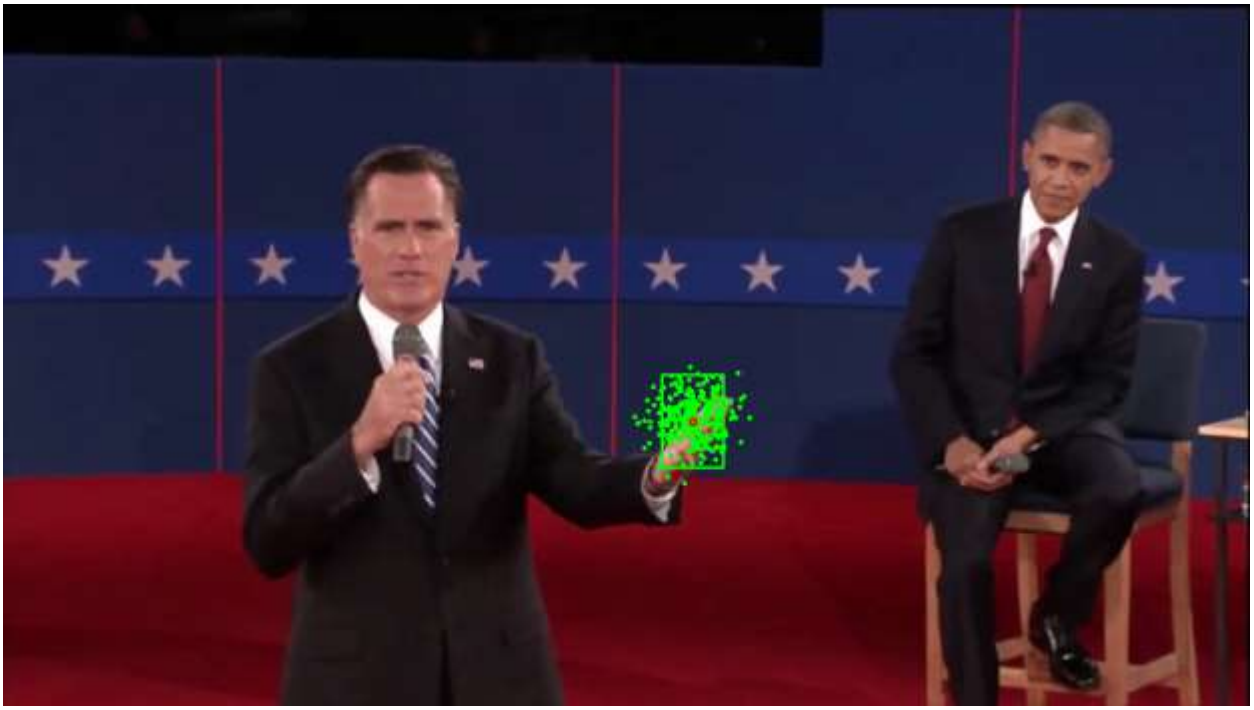

Figure 10: ps7-2-a-3.png Frame 50

Figure 11: ps7-2-a-4.png Frame 140

b. With Noise

σ_{MSE} = 10

σ_{dyn} = 20. I had to increase this above the default value to handle the rapid motion of the hand.

α = 0.5

number of particles = 300

I had the same problems as above with the tracker not being centered. You will notice that these are the same parameters I used without noise, so I did not have to do perform any tuning.

Figure 12: ps7-2-b-1.png Hand template

Figure 13: ps7-2-b-2.png Frame 15

Figure 14: ps7-2-b-3.png Frame 50

Figure 15: ps7-2-b-4.png Frame 140

3. Mean-shift Lite

a. Head tracking

Number of particles = 300

$\sigma_{MSE} = 0.2$

I found I had to use a much smaller value for σ_{MSE} to get good tracking.

Figure 16: ps7-3-a-1.png

Figure 17: ps7-3-a-2.png

Figure 18: ps7-3-a-3.png

Figure 19: ps7-3-a-4.png

b. Hand tracking

Number of particles = 300

$\sigma_{MSE} = 0.1$

$\sigma_{dynamic} = 30$

I did not have much success with using the histograms with hand tracking but I could not figure out why. I tried different numbers of bins and different parameters for the sigma values. The tracking seemed to fail when the hand moved quickly despite there being particles that captured the potential hand locations. When the hand motions were smaller, though, the tracker worked. I did notice as well that there was some confusion between the two hands, which makes sense with a lower dimensional representation of the hand.

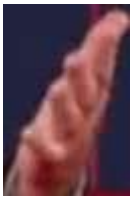

Figure 20: ps7-3-b-1.png

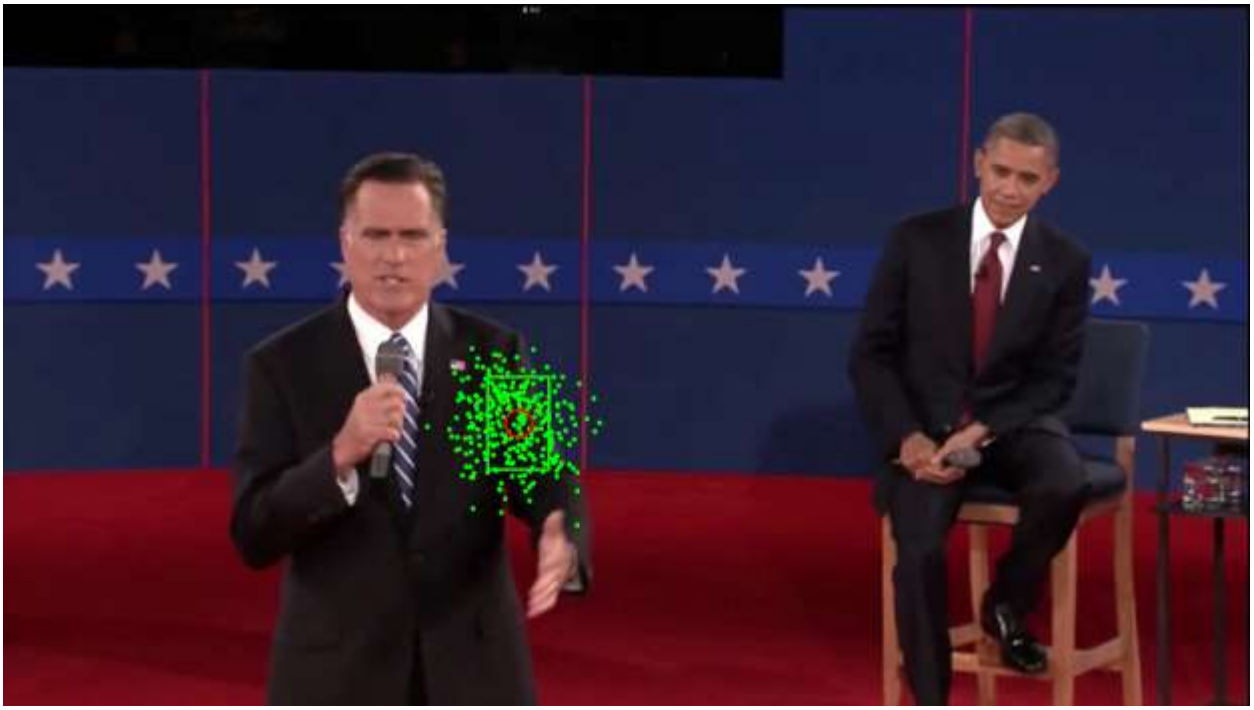

Figure 21: ps7-3-b-2.png

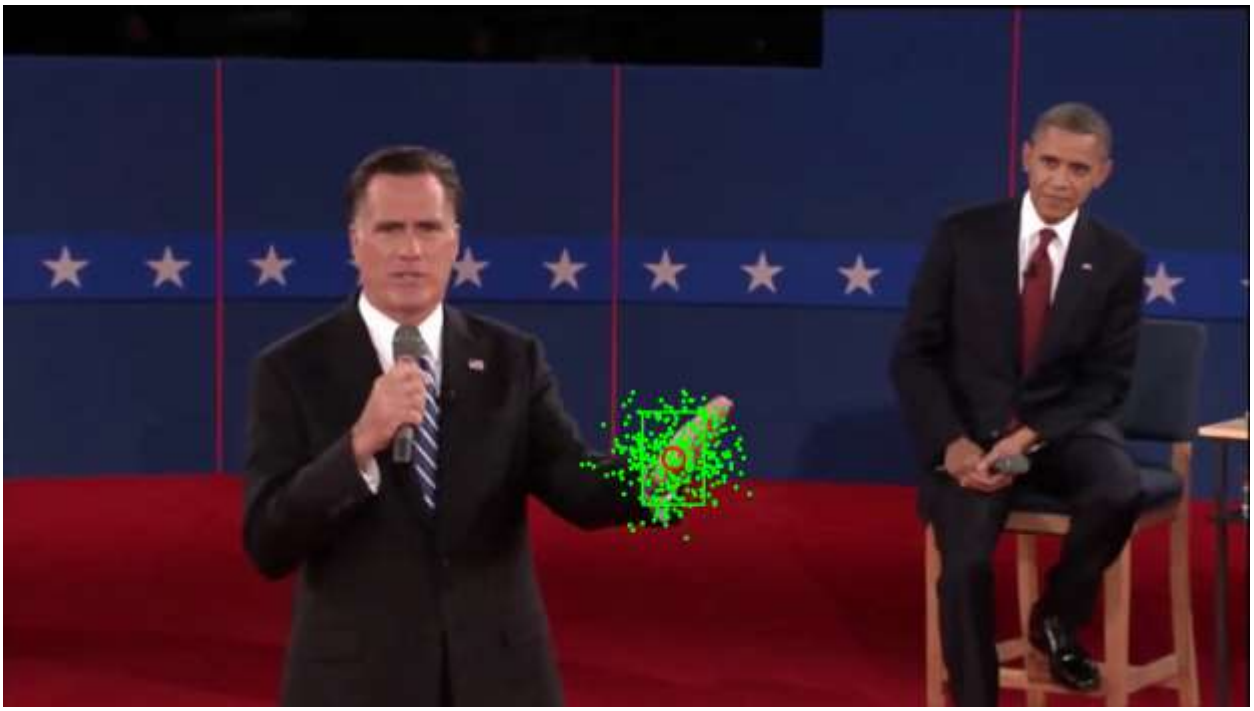

Figure 22: ps7-3-b-3.png

Figure 23: ps7-3-b-4.png