A) Assumptions:

- camera not moving
- tennis ball is ten pixels in diameter
- Tennis ball will contrast with the court
- Assume there is nothing on the court other than the two people and the ball
- High frame rate as the ball is moving fast

RGB video - GMM - moving pixels - cca - moving regions - circularity of the area - circular regions - 10 pixels in diameter - located ball - if ball is within the four corners - mean shift tracking- tracked “balls”

Locating the ball

Firstly I would locate the moving pixels in each RGB frame using GMM. I would then use connected components analysis to find moving regions. I will then locate circular regions using the circularity of the areas. There is a chance that this will locate people’s heads. So I will check how many pixels the diameter is and if it is 10 pixels in diameter. If the ball is within the four corners provided I will use mean shift tracking to track these balls.

RGB video - GMM - moving pixels - cca - moving regions - two largest moving regions - two people - mean shift tracking - tracked “people”

Locating the person

I would use the same system as locating the ball up until finding the circularity. Instead I would locate the two largest moving regions and these must be the people on the court.

Finding the ball bounce

To find a bounce we must check the y position of the ball in each frame. If the y position begins to decrease then the ball must have bounced on the court or the player has hit the ball. There is also the chance that the ball bounced on the net. To ensure the ball did not bounce on the net make sure the x position is not the same as the net. If the ball bounces near the y position of the person then the person must

have hit the ball so the bounce should not be counted. Otherwise the ball has bounced on the court so the location should be recorded.

Plan View

After locating a ball bounce. Using a perspective change with the four corners of the court will give the plan view and the position of the ball bounce can be marked on this.

B)

Gaussian Smoothing	**Median Smoothing**	**Opening**
Smoothing operation	Smoothing operation	mathematical morphology
Reduces noise	Reduces noise	reduces noise
Any image	Any image	Binary image or grayscale
Ruins edges	Preserves edges	Preserves shape
Preserves corners	Damages thin lines and sharp corners	Preserves shape
Computationally efficient	Computationally expensive	Computationally efficient
Linear	Non linear	Non linear
Gaussian noise	Salt & pepper noise	Small blobs of noise

Both Gaussian smoothing and median smoothing are types of smoothing techniques. These are usually applied pre-processing to any kind of image. The opening operation is a type of mathematical morphology which is usually applied to thresholded binary images but can also be applied to grayscale images. All three of the techniques are used to reduce noise.

Both Gaussian smoothing and median smoothing blur the image. Opening reduces noise but maintains region size. Where the Gaussian blurs the edge, median blurring won't blur the edge. The opening won't ruin edges either as it maintains the object shape. Median filtering will blur corners and thin lines where Gaussian smoothing and opening will preserve corners.

Both Gaussian smoothing and opening are computationally efficient; Gaussian due to its linearity and opening as it is based on set operations. Median filtering is computationally expensive with the standard being O(r^2 (log r)).

Gaussian smoothing is a linear operation based on a gaussian function. It uses the pixel kernel to compute the value of the current pixel. Median smoothing is non linear as it uses the median pixel in the kernel. Opening is also non-linear.

All three techniques take their input and process it and then return the image in the same format. For example with opening: binary image is returned as a binary image. With a Gaussian smooth an RGB image is returned as an RGB image.

Gaussian smoothing is appropriate to use on Gaussian noise and median smoothing is appropriate for salt and pepper noise as the noisy pixels are isolated from each other. Opening is useful for blobs of noise.