Hubert Lacôte

Cranfield UNIVERSITY

Image Analysis

Visual Surveillance: Railway Level Crossing Monitoring

Presentation of the techniques used

<u>Detect objects in the scene</u>

To detect vehicles, pedestrians or rail traffic, I realized that one of the simplest techniques was pretty much efficient:

Step 1: Operate a "naïve" *background subtraction* between grey level images.

Step 2: Carry out some *morphological operations* to remove the noise.

Step 3: *Threshold* the result obtained to remove small changes or shadows.

The result of step 1 with the background image in Figure 1 and a sample image in Figure 2 is showed in Figure 3.

Figure 1. Background image

Figure 2. Input image

Figure 3. Background subtraction

I manually tuned different parameters and different morphological operations. The detailed result of step 2 is showed in Figure 4 and in Figure 5. Apply morphological operations *in the grey level images gives better result than applying in a binary image*.

Finally, the result of step 3 is showed in Figure 6 where we only get significant blobs that represent the objects that appear in the scene.

Figure 4. Image after "opening"

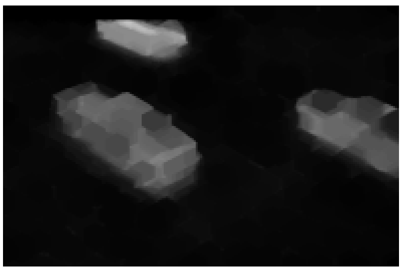


Figure 5. Image after "closing"

Figure 6. Image after thresholding

To obtain better results, I compare every image with 5 backgrounds to see which background is the best. (see Figure 8)

Figure 7. Background subtraction result with the first background image

Figure 8. Background subtraction result with the best background image

From the zones given (see Figure 9), I derived my own zones to detect vehicles and pedestrians (see Figure 10) and to detect rail traffic (see Figure 11).

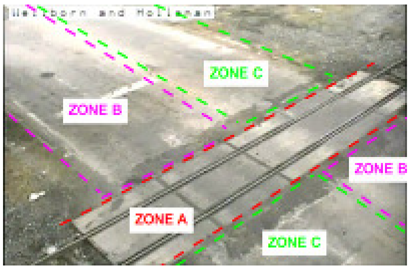


Figure 9. Approximate indication of zones

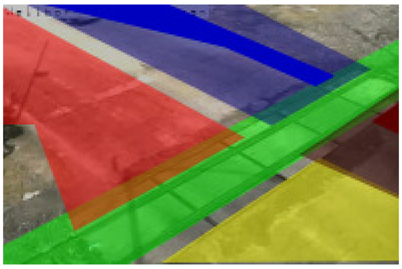


Figure 10. Zones for vehicles and pedestrians detection

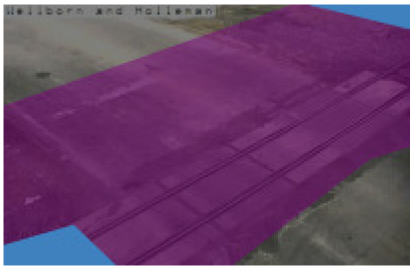


Figure 11. Zones for rail traffic detection

Detect the presence of rail traffic

I only need to compute the area of intersection between the blobs obtained after thresholding and the 3 zones defined in Figure 11, and with 6 conditions manually tuned, I can tell whether or not there is rail traffic. See Figure 12.

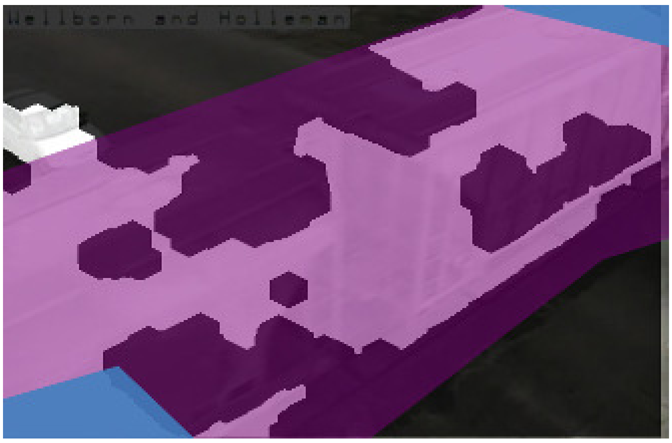


Figure 12. Illustration of the technique

Detect vehicles and pedestrians

I perform basic operations on the blobs obtained after thresholding to know inside which zone they are located:

Step 1: I keep only blobs that have a big enough area.

Step 2: I extract the *contour* of every blob (hull contour for small objects and basic contour for big ones) that gives me their *masks*.

Step 3: I then classify every blob using the *intersection between the mask of the blob and the mask of the zones.* For the right side of the road, I also compute the *centroids of the blobs.*

An illustration of this technique is presented in Figure 13.

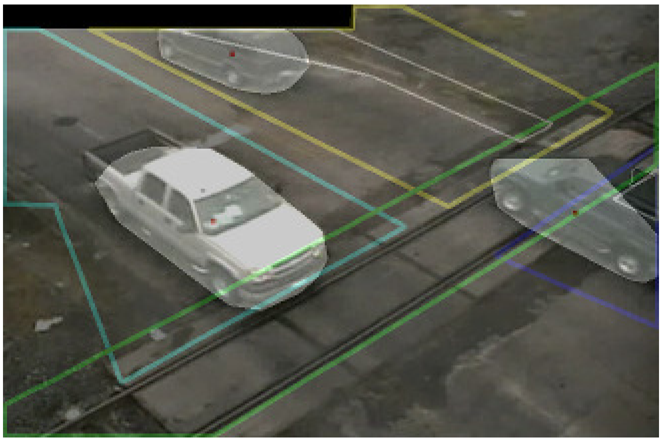


Figure 13. Illustration of the technique

Detect when the barrier is deployed

I first compute the Canny edge detector of the image (see Figure 14), then I apply the Hough Line Transform on the Canny edge detector of the image (see Figure 15). I select only valid lines and from the two best lines, I can then extract the parameters of the line (see Figure 16).

Figure 14. Image with a barrier

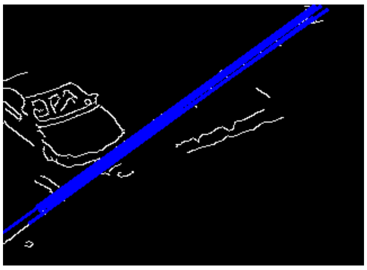


Figure 15. Canny edge detector in white and Hough Lines in blue

Figure 16. Zones for rail traffic detection

I also need to carry out another test to prevent false positive results that occur especially when there is rail traffic.
I use the *Saturation channel* of the *HSV colour space* (see Figure 17) to detect the red stripes of the barrier. I analyze the ratio of red stripes / white stripes for the first four stripes of the barrier. If the ratio is high, it is a barrier, if it is low, it is not. (see Figure 18 and Figure 19)

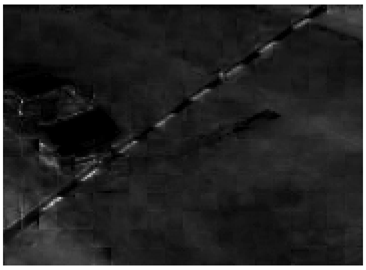


Figure 17. Saturation channel of an image with a barrier

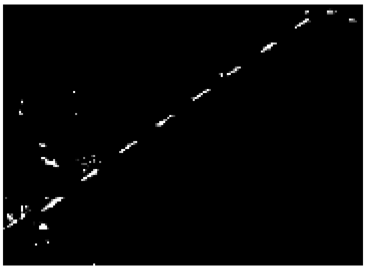


Figure 18. Threshold on the saturation channel

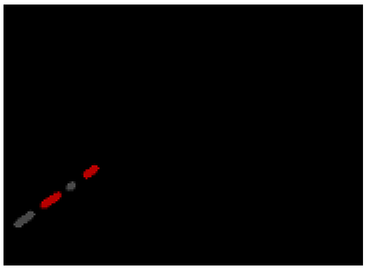


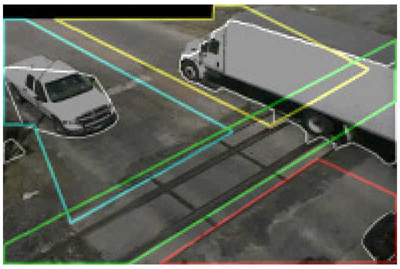
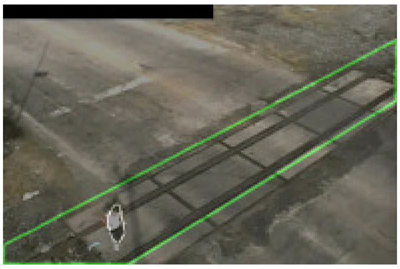
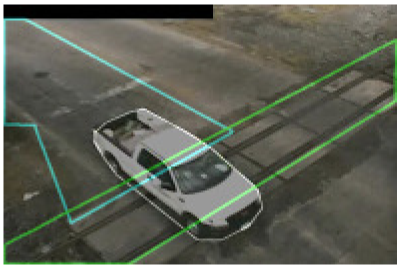
Figure 19. Two masks are automatically generated to compute the ratio

Performance analysis of the prototype

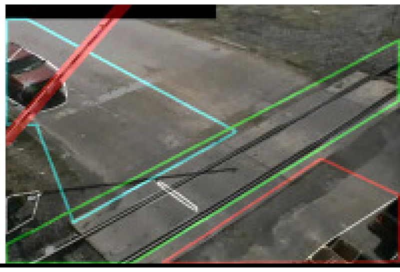
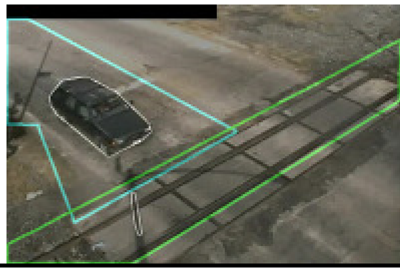
I used the 576 samples images provided to test my prototype.

	True positive	False negative	True negative	False positive
The railway track is not clear of road/pedestrian traffic	177 / 178	1 / 178	396 / 398	2 / 398
	99 %	1 %	**99 %**	1 %

Succeeded

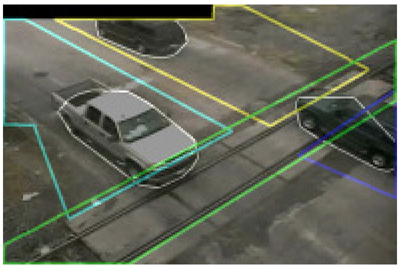
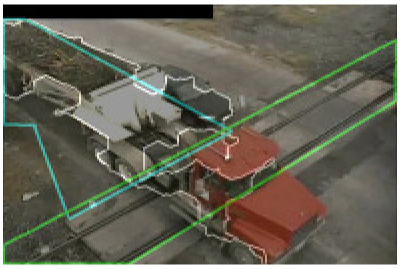
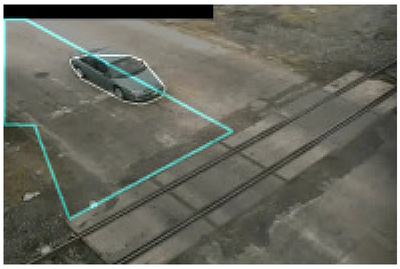




Failed

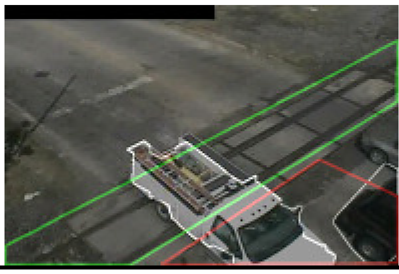
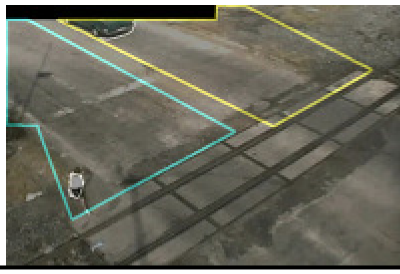




	True positive	False negative	True negative	False positive
A road vehicle is entering the railway line crossing	57 / 58	1 / 58	73 / 74	1 / 74
	98 %	2 %	**99 %**	1 %

Succeeded

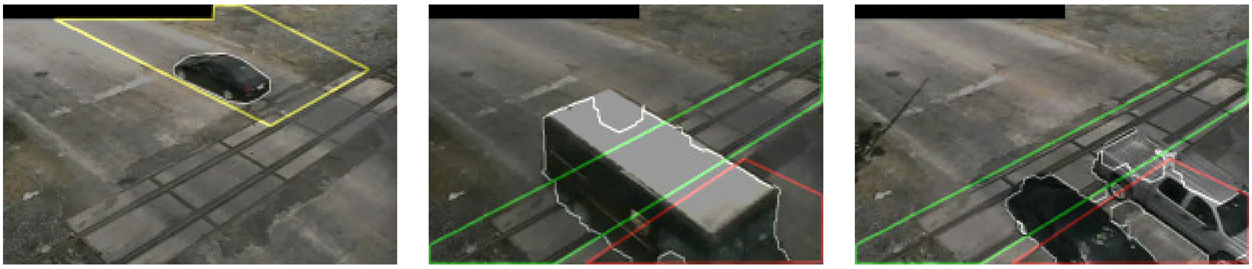




Failed

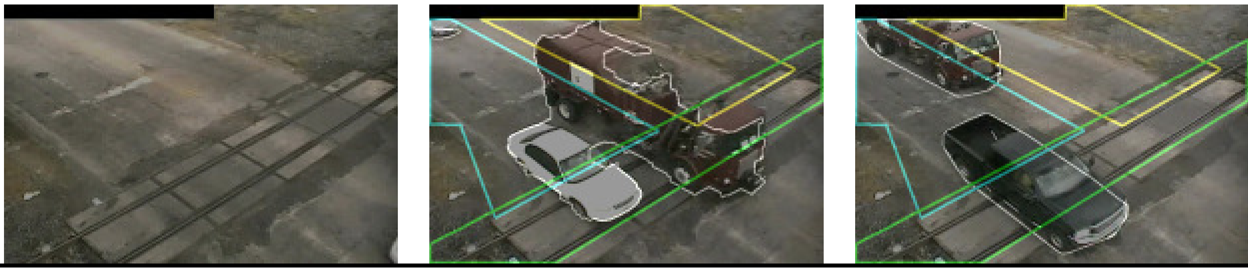



	True positive	False negative	True negative	False positive
A road vehicle is leaving the railway line crossing	58 / 59	1 / 59	44 / 46	2 / 46
	98 %	2 %	**96 %**	4 %

Succeeded

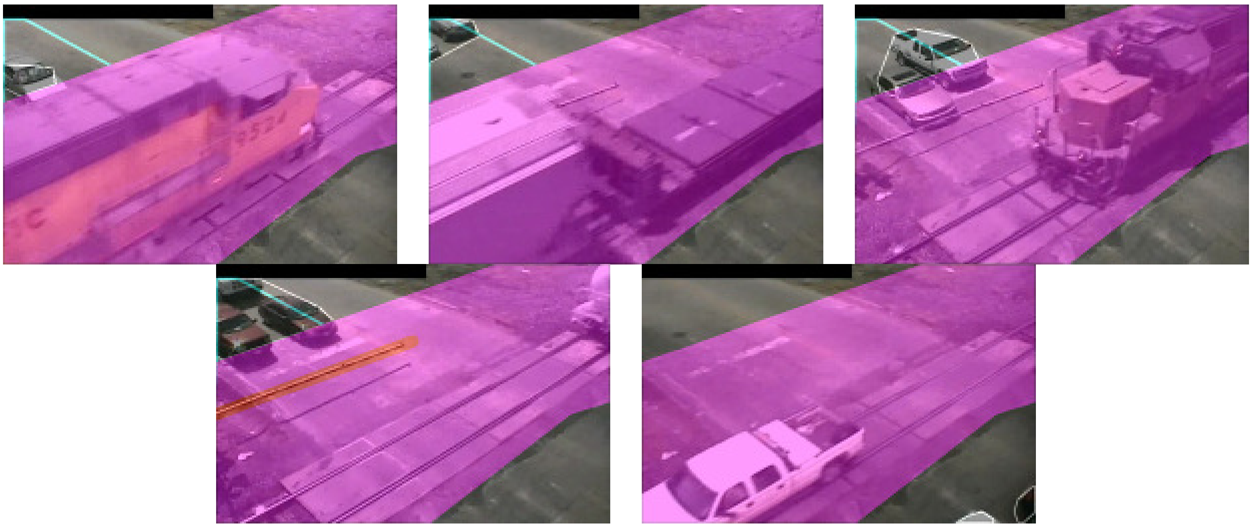


Failed



	True positive	False negative	True negative	False positive
Rail traffic is currently using the railway track	206 / 206	0 / 206	370 / 370	0 / 370
	100 %	0 %	**100 %**	0 %

Succeeded

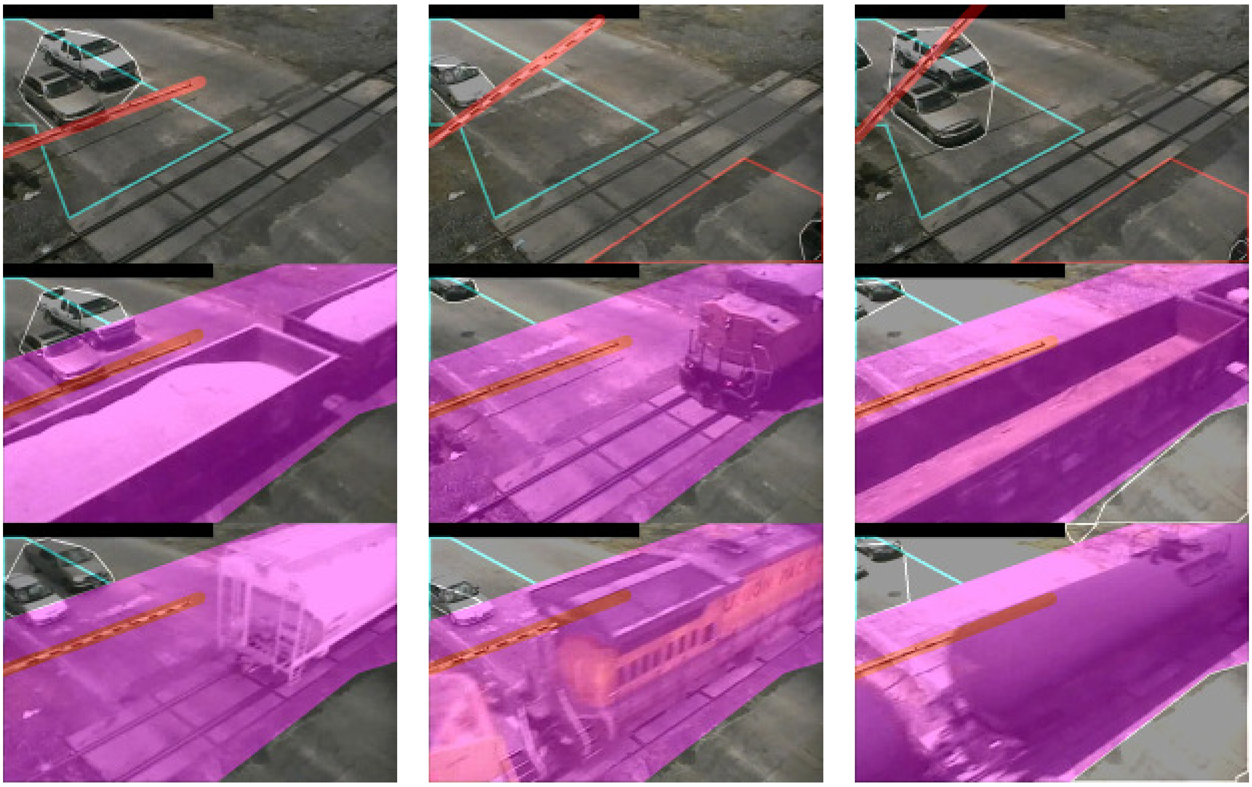


Failed

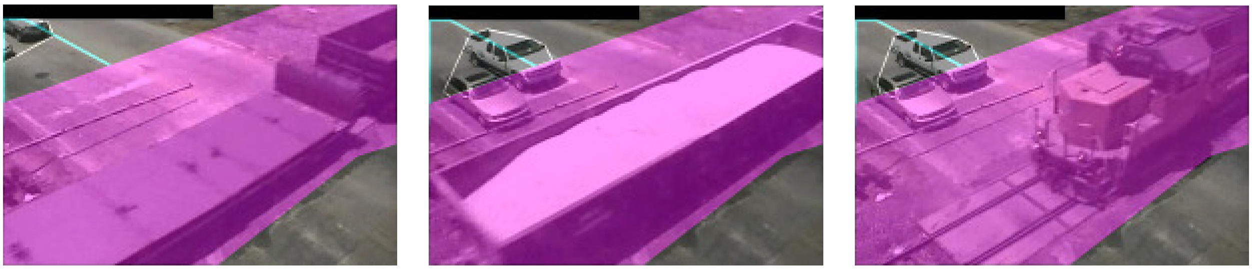
Nothing!

		True positive	False negative	True negative	False positive
The level crossing safety barrier is deployed	when there is no train	32 / 32	0 / 32	339 / 339	0 / 339
		100 %	0 %	**100 %**	0 %
	when there is a train and that we can see the barrier entirely	25 / 63	38 / 63	142 / 142	0 / 142
		40 %	60 %	**100 %**	0 %

Succeeded



Failed



There is no false positive!

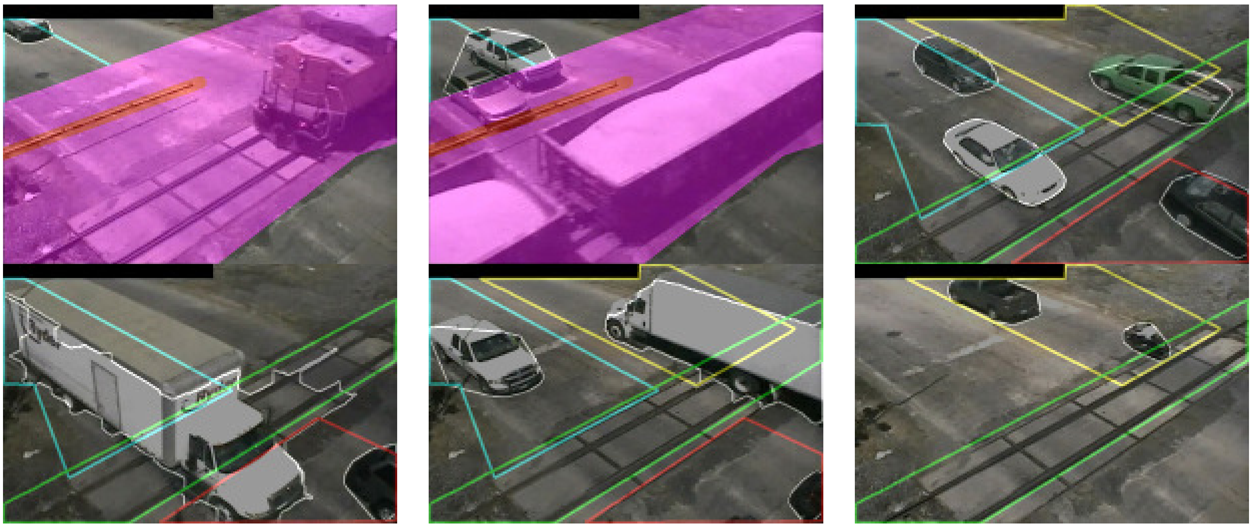
	True positive	False negative	True negative	False positive
No event	556 / 557	1 / 557	19 / 19	0 / 19
	100 %	0 %	**100 %**	0 %

Succeeded

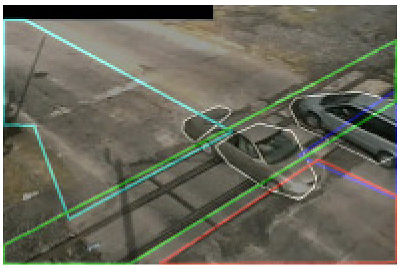
Failed

Combinations of events

Succeeded



Failed



Some vehicles are reported both entering and leaving