Lab$_7$

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1 Introduction

The assignment focuses on detecting and tracking moving objects in given videos divided in several frames. In the first request we use as background an average of two given frames, while in the second and third ones we use a background model based on running average to incorporate scene changes. The last request is about multiple objects tracking where the goal is to keep track of the entire trajectories and produce a visualization.

2 Materials/Methods

The laboratory is carried out on MatLab. The core of the program is the change_detection function, where the images are uploaded and all the steps are completed.

In the first step we compute the background averaging two initial frames using the formula $M_t(x,y) = 1$ if $|I_t(x,y) - I_{ref}(x,y)| > \tau$ and 0 otherwise. M_t is a binary map where the values set at one are where there is motion.

Going forward we notice that the scene may change because of permanent variations, light change and so many other factors and we realize that a single constant background model is not enough to detect objects correctly. That's the reason why we choose to design a background model that is updated at each time instant using the "Running average" method, whose improvements are that it is quite robust to moving objects in the scene, it incorporates stable changes (at a speed which is proportional to *alpha*) and that it is simple and computationally efficient. The main positive effect produced by using this method is that it does not deal with repetitive and uninteresting motion.

The formula of the Running average method is quite similar to the previous one, but with a difference: instead of using a fixed value for $I_{ref}(x,y)$ we use the background calculated previously (B_{t-1}). The next step is to calculate the background that we are going to use in the next frame with the formula: $B_t = B_{t-1}(x,y)$ if the pixel is moving and $B_t = (1-\alpha)B_{t-1}(x,y) + \alpha I_t(x,y)$ if the pixel is static. α is the variable that controls the rate at which the background incorporates the static pixels. We say that a pixel is moving if the absolute value of the intensity of that pixel minus the intensity of the same pixel in the previous frame is grater than a certain threshold.

The last part of the assignment concern the topic of tracking objects. Using the running average method we obtain the binary map that allows us to detect motion and by using the Area field of the MatLab function "regionprops" we are able to consider only the largest areas that are moving, that we identify as objects.

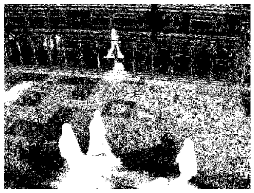
We proceed bounding the objects that we find. Using the position of the centroid of each object we are able to keep track of it from one frame to another. To do that we check if the centroid of the object in the current frame is within a certain distance from the one in the previous frame.

3 Results

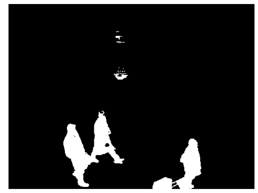
In the first task we obtained the background and the binary map of each frame, as explained in Methods/Materials. In Figure 1 can be seen an example.

Figure 1: Left: Original image; Center: Background; Right: Binary map

We can notice the value of τ is inversely proportional to the sensitivity of the detection of motion, so if it is too small the effect of the noise is very noticeable while if it's too big it might not detect all the motion as we can see in Figure 2.



(a) Smaller τ



(b) Bigger τ

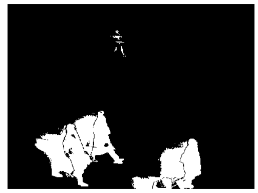
Figure 2: Binary maps

In the second and third task we use the running average, as explained previously, to obtain the binary map and a background that updates every frame. In Figure 3 can be seen the last frame of the sequence that we use in the second task.

Figure 3: Left: Original image; Center: Background; Right: Binary map

The α parameter is used to control the rate at which the objects are incorporated in the background. In figure 4 we can see the effects of a smaller α.

(a) Background



(b) Binary map

Figure 4: Small α

As we can notice, with a really small α, it takes a long time to incorporate changes in the background and because of that we obtain a "trail" effect. We can notice that the moving objects appear very blurred in the background and in the binary map there is a trail behind every moving object.

In figure 5 we can see the effects of a bigger α.

(a) Background

(b) Binary map

Figure 5: Big α

A big α has of course the opposite effect of a small one, it takes very little to incorporate changes in the background. We can notice that the moving objects are fairly sharp in the background and as a consequence of that the motion is detected only on the edges of the objects. This is due to the fact that while the people are moving, the inside of the objects appear static, because they have pretty much a constant intensity, while the motion is detected at the edges because there is a great change of intensity between the people and the floor.

The last task, as explained in Methods/Materials, revolves around the topic of tracking. In Figure 6 it can be seen a frame of the video with the object tracked and labeled.

Figure 6: Left: Original image; Center: Background; Right: Binary map

The method that we use to track the object is very simple, so, of course, it has some flaws but it behaves accordingly to our expectations. As explained previously we use the position of the centroid to recognize an object from one frame to another one. While this method works well with the person on the right, it has problems with the two men walking together. In figure 7 we can see the trajectory of the man on the right.

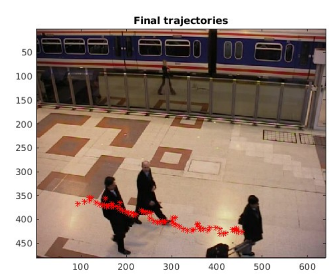


Figure 7: Tracked trajectory

The program is able to track him correctly because he is alone. The other two men, on the other hand, are sometimes recognized as a single larger object and sometimes as two individual objects, so the program, in the moment that the split happens, creates a new object and when they become a single one again they overlap. As the video goes forward, more and more objects are created and as we can see from Figure 6, when they merge back in a single object all the labels overlap. We tried to modify the threshold that specifies the distance of the centroid from one frame to the previous, but it didn't improve anything and it also created some problems with the man on the right.