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Object Distance Detection from Surveillance Cameras

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Abstract- Currently object detection and recognition in an image are of vital importance, and, as such, widely used in a number of fields, such as video surveillance systems [1, 2], medical imaging, underwater scanning, etc.

Localization of an object detected in an image or area monitored by a surveillance camera has a primary role. Localization implies calculation of an object distance from a video camera by defining the object's depth in an image [3]. Object localization will allow easy plotting of its geographical coordinates which, in turn, will give surveillance operators considerable scope for action.

Keywords-*Object Detection and Recognition, Distance Calculation, Surveillance, Coordinates Detection, Image Depth*

I. INTRODUCTION

In cities where all the streets are equipped with surveillance cameras, police will be able to detect the exact coordinates of pursued vehicles. If a vehicle is in motion, by receiving constant updates on the coordinates and their mapping, law enforcement authorities will be able to track vehicles and apply further preventive measures.

On the whole, localization is essential for the solution of many other issues as well [4, 5]. This article discusses an object localization method in an image, and describes tests and technical solutions which have been obtained.

II. METHOD DESCRIPTION

Different surveillance cameras have different shooting angles (90^0, 120^0, 180^0), based on which the field of view available for surveillance cameras in an image is determined.

The developed method is relevant to all fields of view angles of all surveillance cameras.

Proceeding from a surveillance camera type, the field of view is always evident. We will carry out the testing on a 90^0 angle surveillance camera.

Picture 1 illustrates the topology of any area in which a surveillance camera field of view is demonstrated.

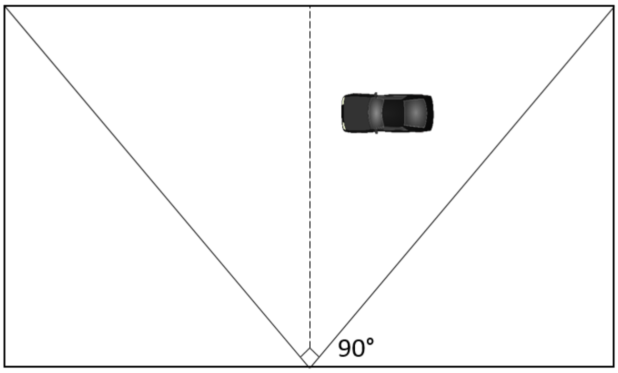

Figure 1. Area Topology and Surveillance Camera Field of View

In case of figure 1, we have the object's profile view (see figure 2). The object has a width which can be measured by pixels (after detecting the object by its separation from the background, the number of pixels is revealed). Following object recognition, we can now identify it as an automobile, preliminarily having the templates of the latter.

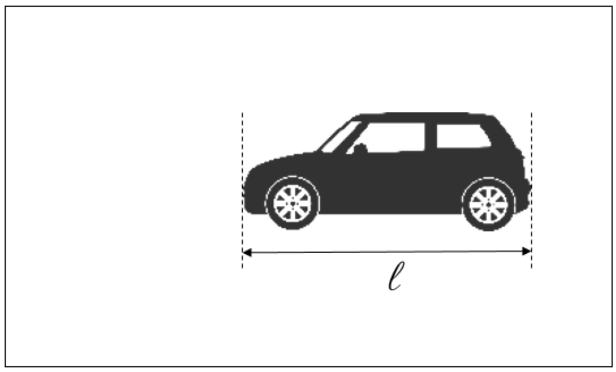

Figure 2. Profile View of the Object

Let's take a look at one template example of an automobile.

First of all, we will take an automobile with the width of l and place it on distance a_1 (see figure 3). The distance a_1 is selected so that the beginning and the end of the automobile are positioned in the parts adjacent to the edges of the image; the width of the image equals l.

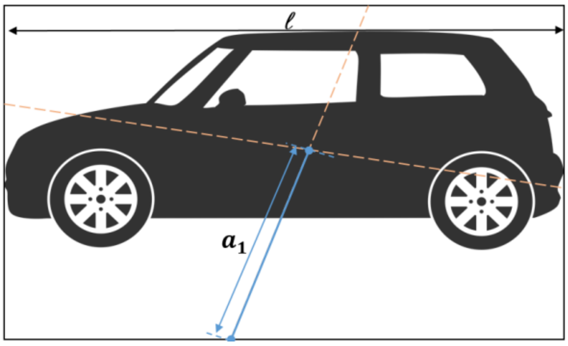

Figure 3. Automobile Template

In figure 3 a_1 shows the depth – distance from the surveillance camera.

Let's look at an example, when, while being in the surveillance area, on an unknown distance h an object is detected [1, 2]. The object is recognized, and its image coincides with the automobile image described in the previous example (figure 4).

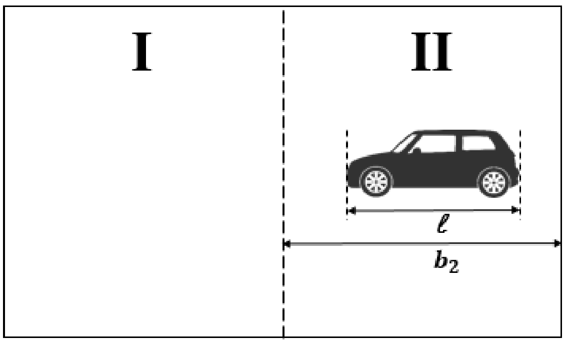

Figure 4. Detected Automobile on Distance h

Let's devide the field of view of the surveillance camera into two segments – I and II. It can be seen that the automobile is detected in segment II. Let's consider the topology of the image for segment II (figure 5). In figure 5 the automobile with the length of l detected on distance h is depicted on segment FH. If we take the automobile template illustrated in figure 3, segment II will display half of the automobile, which will have length $\frac{l}{2}$. We will depict it on segment BC (figure 5).

It is possible to calculate distance AG (which is just h) -the main objective of this article. Applying the Pythagorean Theorem we can calculate AG by sides DG & AD (Formula 1).

$$AG = \sqrt{AD^2 + DG^2} \tag{1}$$

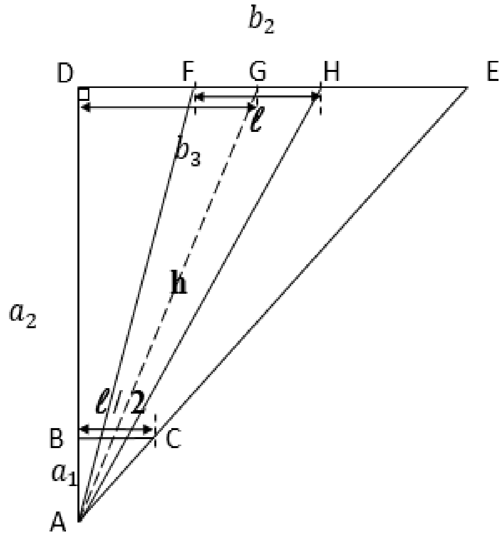

Figure 5. Topology of Segment II of the Image

However, sides DG and AG are unknown. Firstly, we will calculate AD applying the criteria of similar triangles. Let's assume ABC and ADE are similar triangles with sides a_1, b_1, c_1 and a_2, b_2, c_2. BC is $\frac{l}{2}$.

$$\frac{BC}{DE} = \frac{AB}{AD} \tag{2}$$

Hence,

$$AD = \frac{AB \cdot DE}{BC} \tag{3}$$

In Formula 3 AB and BC are known quantities. Let's calculate DE (b_2). Figure 4 will help to calculate the number of pixels corresponding to length l of the vehicle. On segment l we will define the number of pixels as l' and on b_2 segment - b_2':

After object detection, their x_1, y_1 and x_2, y_2 pixel coordinates on the image are known (figure 6).

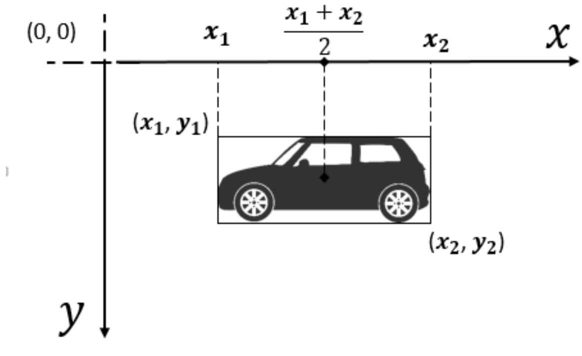

Figure 6. Detected Object Pixel Coordinates

l' is calculated as follows (Formula 4):

$$l' = x_2 - x_1 \quad (4)$$

b_2' can be calculated similarly by taking the coordinates of the image midpoint and its right-side coordinates X:

b_2 can be calculated with the help of Formula 6 which is just side DE:

$$\frac{b_2}{b_2'} = \frac{l}{l'} \quad (5)$$

$$b_2 = b_2' \frac{l}{l'} \text{ (m)} \quad (6)$$

Using the latter in Formula 3we can calculate AD (a_2) (Formula 7 and Formula 8) :

$$a_2 = 2\frac{a_1}{l} \cdot b_2' \frac{l}{l'} \quad (7)$$

$$a_2 = 2a_1 \cdot \frac{b_2'}{l'} \quad (8)$$

Let’s find side DG (b_3) both for b_2 and b_3 (Formula 9):

$$b_3' = \frac{x_1 + x_2}{2} \quad (9)$$

$\frac{x_1 + x_2}{2}$ is coordinates X of the detected object midpoint.

Using Formula5 and Formula 6, b_3 (DG) can be calculated with no efforts (Formula 10):

$$b_3 = b_3' \frac{l}{l'} \quad (10)$$

Applying DG և AD in Formula 1, AG can be calculated (Formula 11):

$$h = \sqrt{4\left(a_1 \frac{b_2'}{l'}\right)^2 + \left(b_3 \frac{l}{l'}\right)^2} \quad (11)$$

III. Conclusion

Object templates have been generated. Using the templates, a number of tests have been carried out with objects of various sizes and positions being placed on various distances from surveillance cameras. As a result, a method has been developed, which allows determining the distance of an already detected and identified object in an image from a shooting point – the surveillance camera. Different surveillance cameras have different shooting angles (based on which the field of view available for a surveillance camera in an image is defined). The method is relevant to all surveillance cameras and field of view angles. The theorem of similar triangles has been used to perform the method. It is effective and allows precise calculation of distances of various objects from surveillance cameras.

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