An Effective Method to Test the Effectiveness of a Reference Template

Saja S. Azeez, Loay E. George, Faisel G. Mohammed
Computer science/Baghdad University
Baghdad

Abstract— most, if not all, of the camera surveillance sensing applications require change detection. Change detection is one of the most important computer vision processes. It aims to detect the changes in a scene over time. Also, the moving objects detection and classification in a dynamic scene is an important area of research in computer vision. Such applications deal with visual sensors, usually stability of such sensors' is affected by weather conditions, it may experience some vibrations, and these vibrations may significantly affect the captured samples of a scene and cause defects in the results of samples comparison (pixel-by pixel operations). To form this comparison, it is necessary to spatially register the images samples, and thereby, to correct for relative translation (shifts) under small variations in both scale and rotations. The samples registration requires a template area to be used as a reference block for the assessment of shifting compensation parameters. This template should be unique relative to its surrounding area in order not to mis-match the reference block template with another block and it should have high contrast, it is vital to be easily identified from its surroundings area. In this research an effective method to test the effectiveness of the reference template is proposed. The obtained results from applying the proposed method indicated encouraging performance when implemented on different templates.

Keywords— distance measures, features blocks, auto image registration, image translation compensation.

I. INTRODUCTION

Scene changes and motions can be detected using either temporal difference or background subtraction [1]. These methods provide a classification of pixels into either foreground (moving objects) or background [2]. When the background subtraction method is used to detect the changes, a reference image should be available to compare the captured samples against it. The RT is selected from the reference image. In this research, roads' samples are used for illustration purpose. Section (2) presents a general flowchart of the proposed method, in section (3) the reference template properties are illustrated (4) the test area selection is illustrated, in section (5) the used distance measure is given, in section (6) the conducted test procedure is given, section (7) shows the shifting parameters determination is illustrated (8) the experimental results are listed, and in section (9) conclusions are given.

The proposed method utilizes modified computer vision techniques to meet the needs of testing the RT and identifying the shifting parameters.

II. THE FLOWCHART OF THE TESTING METHOD

Figure (1) shows the general steps for the testing method. The method starts with step of RT selection from the reference image, then testing this selection correctness. The selected template should satisfy both high contrast and large uniqueness. In this research the template is selected manually.
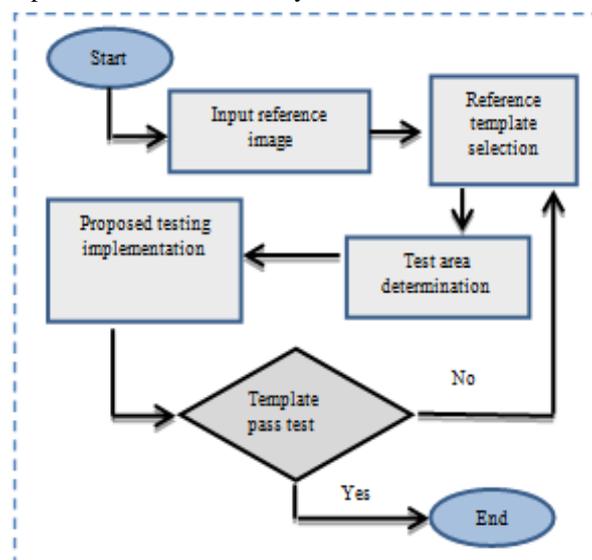

Fig. 1 A general flowchart of the proposed method

III. THE REFERENCE TEMPLATE PROPERITES

The RT should be selected carefully and correctly. It should not be significantly subjected to any changes except illumination changes. The user should be trained to select the proper RT. Its contrast should be high, it is vital to be easily identified from its surrounding area. It should be unique relative to its surrounding area; because if there are more than one block the system may use the wrong block. It should not be selected to be close to any of the image edges; because it is vital to ensure that the RT stays within the camera view whatever the vibrations may occur on the camera.

IV. TEST AREA DETERMINATION

The test area is determined based on the camera (or its holder) vibrations severity and on the application time limits. Large test area requires large time to be tested.

In the following example 10 samples were used to deter-mine the effect of RT size. These samples suffer from some vibrations, a RT is selected manually from the reference image and it is sought within the 10 samples, the number of correctly found templates will indicate the suitability of the chosen size.

TABLE I

THE EFFECT OF RT SIZE

Test Area Size	Num. of Found Templates	Number of Missed Templates
1×1	0	10
2×2	0	10
3×3	2	8
4×4	4	6
5×5	7	3
6×6	8	2
7×7	9	1
8×8	9	1
9×9	10	0
10×10	10	0

From table (1) the size of the search area is 9×9 (or 10×10) is the most suitable size, because the RT is found in all test samples. Figure (2) shows one of the 10 samples and the RT marked in red.

Fig. 2 road sample and the reference template.

V. DISTANCE MEASURES

The most common similarity measures used in image processing are the Euclidean distance measure and the city-block (i.e., the chessboard) distance measure.

The D4 distance (also called city-block distance, Manhattan distance, and absolute value metric) is an approximation to the Euclidean measure; it is computationally faster. The distance between the pixels (p) & (q) with the coordinates (x, y) & (s, t), respectively, is defined as follows [3]:

$$D_4 = |x-s| + |y-t| \tag{1}$$

VI. THE PROPOSED TESTING METHOD

In this research the RT is selected from the reference image, a 10×10 search area is opened around the RT to track the template within the search area.

A. The Proposed Contrast Testing Method

Contrast describes the local relation between the brightness values in an image or a section of an image. As a measurement for the degree of contrast the Michelson's contrast measure is widely used [4]:

$$Contrast = \frac{I_{max} - I_{min}}{I_{max} + I_{min}} \qquad (2)$$

Whereby the largest-appearing brightness value, in the neighbour area, is indicated by Imax and the smallest appearing brightness value is denoted by Imin.

In the proposed method the contrast value of the selected RT is tested in reference image and be sure it has the highest contrast template within the local region surrounding the RT area.

Here, in our proposed method the template's contrast is calculated using the following criterion, instead of Michelson measure:

$$Contrast = \frac{M_H - M_L}{255 - \frac{1}{2}(M_H + M_L)} \qquad (3)$$

Where, MH is the mean of the block's gray values that are higher than the block mean value, and ML is the mean of the block's gray values that are less than the block mean value.

The contrast measure, defined by equation (3), assesses more properly the templates that have high contrast then the templates chosen by using the measures given by equation (2). The later usually lead to choosing template blocks that have dark high contrast. Figure (3) presents the attained results for illustration; where the red templates are selected manually and the blue templates are the templates that are candidate by equation (2) and equation (3).

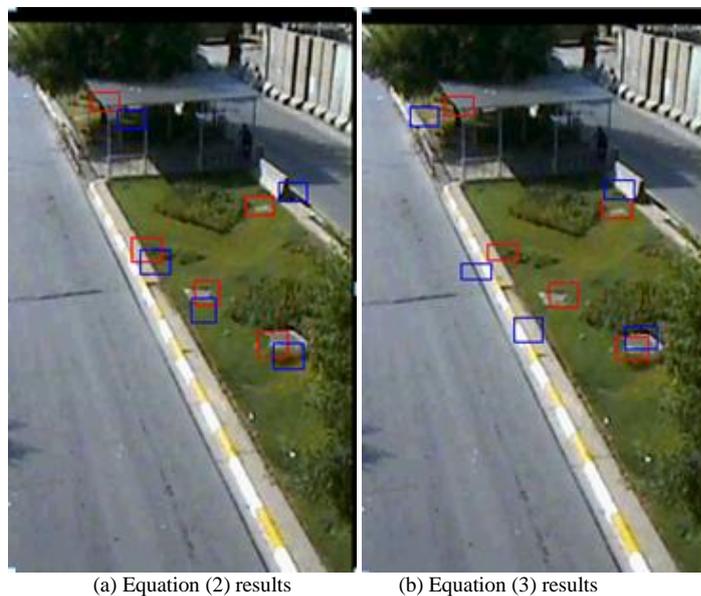(a) Equation (2) results   (b) Equation (3) results

Fig. 3 A comparison between the manual and auto selection of RT

For the purpose of template matching between the RT and the block candidate lay in other corresponding image frame a relative contrast measure is suggested. It is used to assess the degree of contrast similarity between that for RT and that for the nominated block. Let the contrast of then RT is CRT and that for the nominated block is CB. The relative contrast difference (RCD) between CRT and CB is determined using:

$$RCD = \frac{C_{RT} - C_B}{C_{RT}} \qquad (4)$$

Where, CB value is the contrast value of any other selected template in the surrounding (RT). The smaller the difference the better the nominated block for RT, because the reference template's contrast value should be close to the contrast value of the template; that is candidate earlier.

B. The Proposed Uniqueness Testing Method

The RT uniqueness is tested in terms of the smallest colour differences found when RT is matched with blocks found in the neighbourhood area. In order to find the blocks that have closest colour to RT, the mean absolute difference (MAD) is used as a block matching measure, it is determined using the following:

$$MAD = \frac{1}{HxW} \sum_{y=0}^{H-1} \sum_{x=0}^{W-1} \{ |r_1(x,y) - r_2(x,y)| + \qquad (5)$$

$$|g_1(x,y) - g_2(x,y)| + |b_1(x,y) - b_2(x,y)| \}$$

Where H is the reference template's height, W is the reference template's width, r1, g1, b1 are the RGB of reference template's pixel (x, y), and r2, g2, b2 are the RGB of the pixel (x, y) that belong to the tested block as a reference template in the tested image frame.

The result of MAD for all of the possible templates is stored in an array; let the array be arr(). The array size equals to the number of possible templates. This array is sorted on ascending order. The best matching templates will be at the beginning of the array. The value of arr(0) will be zero because it is the result of testing the RT with itself.

The test is implemented between the first closest template arr(1) and the tenth closest template arr(10), because they are considered to be blocks belong to the set of blocks that are most similar to RT (i.e, in their RGB values and position).

When the difference between the templates MAD values is big then the reference template's uniqueness degree is considered high. The suggested uniqueness measure is:

$$Uniqness = \frac{arr(\,10\,) - arr(\,1\,)}{arr(\,1\,)} \qquad (6)$$

This equation is based on the relative difference of two color difference values; it is an indicator to the local growth of color difference between the selected RT and its neighbor. It is not necessary to take the tenth template; higher number can be used in the test; but this index order (10th) is used be-cause it is most probably be very close to RT in position (i.e. the tenth close template is mostly shifted by two pixels from the default reference template.

Sometimes, a small shift may produce a very big MAD between RT and the neighbor block, in such case the selected template can be considered as perfect unique template. Figure (4-a) shows the lowest registered MAD values for the blocks lay within the surrounding area for RT. Figure (4-b) shows the lowest registered MAD result for the 10 closest templates to the reference template.

The blue series shows a big and rapid change as a result of selecting a unique template while the red series shows opposite behavior as a result of selecting non-unique tem-plate.
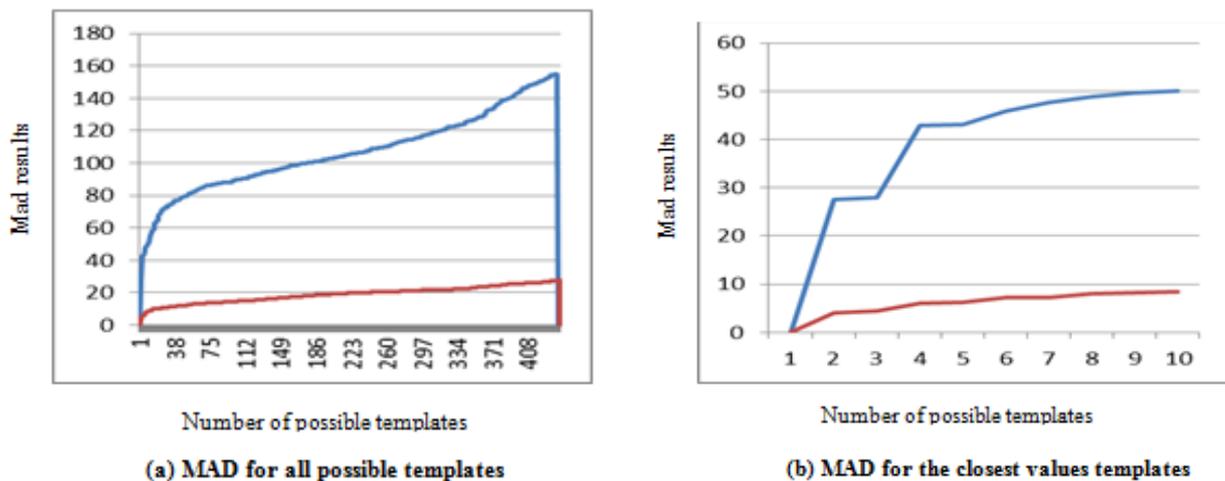

(a) MAD for all possible templates   (b) MAD for the closest values templates

Fig. 4 Uniqueness test comparison charts

C. The Test Algorithm

Reference template testing Algorithm
Input: reference image (RI)
Output: the accepted (RT) coordinates
Begin
Step1: Select a template from the RI that would be
         considered as a RT.
Step2: Calculate RT contrast value using eq. (3), and set the value to be TC.

Step3: Open (10×10) test area in the RI around the selected template, and do the following:
        For all possible templates within the test area
            Find MAD between RT and current possible template using eq. (5) and put the result in
            array, set the array to be unqs(bnum), bnum is the current possible template number.
        Increment bnum value by 1.
         Find the highest contrast template within the test area using the eq. (3), and set its
        contrast value to be HC.
      End loop

Step4: Sort the unqs(bnum) in ascending order and get the first unqs(1) and the tenth unqs(10)

values.

Calculate the relative difference to test the block uniqueness using equation (6) and set it to be udiff and the relative difference to test the block contrast using equation (4) and set it to be cdiff.

Step5: If udiff > uth1 and unqs(1) < uth2 and then

Go to step1. //uth1 and uth2 are uniqueness thresholds

Else

If cdiff > cthr1 and BC < cth2 then

Go to step1. // cth1 and cth2 are contrast thresholds

Else

Save the accepted RT coordinates

End if

End if

END

VII.   SHIFTING PARAMETERS DETERMINATION

Before the step of determining the change between two samples, the shift parameters should be determined as follows:

1. The best nominated template (RT) should be defined in the first image sample, and its top-left corner coordinates (x_{RT}, y_{RT}) should be registered.
2. The best nominated template should be found in the second image sample, and its top-left corner coordinates (x'_{RT}, y'_{RT}) should be allocated.
3. The shift parameters $(\Delta x = x'_{RT} - x_{RT}, \Delta y = y'_{RT} - y_{RT})$ are calculated from the pair of coordinates.

VIII.   EXPERIMENTAL RESULTS

The results of the tests conducted different images samples have stimulated many remarks. Two thresholds are required to test the uniqueness of the RT (i.e., uth1 and uth2), and two other thresholds to test the contrast (i.e., cth1 and cth2).

The thresholds uth1 and cth1 are not enough to determine that the template is unique and has a high contrast; because the relative difference measure for the high and low values produce the same results. For example: $((100-90)/90=0.1$ and $(10-9)/9=0.1)$. This means that the unique and the non-unique templates pass uth1 test; the high contrast and the low contrast templates pass cth1 test; therefore uth2 and cth2 are used to filter the results.

For the experimented samples the default value of uth1 is set 1.5 and for uth2 is set 20; while the value of cth1 is set 1.1 and for cth2 is set 0.1. When these values are changed the following have been preserved:

1. Reducing (uth1) exacerbates unique templates acceptance; and increasing it leads to accept templates that should be rejected.
2. Reducing (uth2) leads to accept templates that should be rejected, and increasing it exacerbates unique templates acceptance.
3. Reducing (cth1) exacerbates high contrast template acceptance, and increasing it leads to accept templates that should be rejected.
4. Reducing (cth2) leads to accept templates that should be rejected, and increasing it exacerbates high contrast template acceptance.

XI.   CONCLUSION

In this research an effective method for evaluating the correctness of RT have been proposed and tested. And the shifting parameters for the shifting compensation are determined. The test results indicated the effectiveness of the proposed measures in this article.

REFERENCES
[1]   Paolo Remagnino, Dorothy M. Monekosso, and Lakhim C. Jain, *Intelligent Paradigms in Security Innovation in Defence Support-3*, Springer-Verlag Berlin, 2011.
[2]   Shireen Y. Elhabian, Khaled M. El-Sayed, and Sumaya H. Ahmed, "Moving Object Detection in Spatial Domain using Background Removal Techniques - State-of-Art", Bentham Science Publishers Ltd., 1874- 4796 /08, 2008.
[3]   Rafael C. Gonzalez, and Richard E. Woods, *Digital Image Processing*, 2nd Edition, Prentice-Hall, 2002.
[4]   Andreas Koschan, and Mongi Abidi, *Digital Color Image Processing*, John Wiley & Sons Inc., Hoboken, New Jersey, 2008.