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Template Matching Technique using Enhanced SAD Technique

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***Abstract*— Translational template matching addresses the registration problem and has long been a problem of interest in such areas as video compression, robot vision, and biomedical engineering. Fast Fourier transforms (FFTs) have been called one of the ten most important algorithms of the twentieth century. Using some substitutions and complex arithmetic, computation of sum absolute difference derived is to be correlation functions of substituting functions. The former can be computed using the fast Fourier transform (FFT) approach, which is greatly less computationally expensive than the direct computation. The performance of the proposed methods, as well as some illustrative comparisons with other matching algorithms in the literature, is verified through simulations.**

The NCC metric is always suffering to locate the face especially in the images with illumination variations. In this paper we proposed a fast template matching technique based on similarity measurement metrics namely: Enhanced Sum of Absolute Difference (E-SAD) to overcome the drawback of NCC. NCC is affected by illumination and clutter background problems because sometimes there are non-face blocks that have almost the same value of the average face template matrix. This problem can be solved by using Sum of Absolute Differences algorithm (SAD) which is widely used for image compressing and object tracking but still SAD needs more optimization to give more accurate positions for face in the input image. Moreover, SAD can give high localization rate for facial where the image is with high illumination variation but it may be affected by variation in background [4].

Keywords*— Convolution, Normalized Cross Correlation, Sum of Absolute Difference, Pattern Matching, Template Matching Fast Fourier Transform.

INTRODUCTION

Template matching is a common tool in many applications, including object recognition, video compression, stereo matching, and feature tracking. It has been used for video applications other than sequence coding such as motion compensated spatial temporal interpolation motion compensated enhancement. The SAD (sum of absolute differences) is another commonly used similarity metric. The algorithms which have been developed to speed up the process of sum of absolute difference (SAD) matching are designed exclusively in the spatial domain. Although there are many approaches whose objective is to speed up the process of SAD matching, they can only give the position of the SAD minimum. When the distance SAD should be calculated for every location in the image, the direct SAD computation requires more much time. Authors have proposed to expedite this naive approach using the FFT transform while exploiting the Fourier correlation theorem [2].

I. METHADOLOGY

A. *CONVOLUTION METHOD*

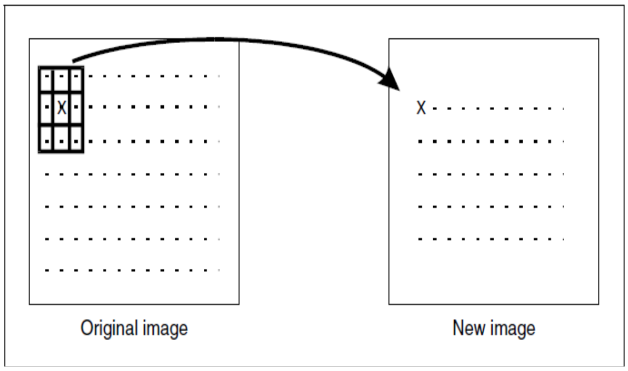

Fig. 1 Template convolution process [5].

B. *NORMALIZED CROSS CORRELATION (NCC)*

Normalized cross correlation (NCC) has been commonly used as a metric to evaluate the degree of similarity (or dissimilarity) between two compared images. The position of a given image pattern in a two dimensional image I. Let I(x, y) denote the intensity value of the image I of the size M x N at the point (x, y), $x \in \{0,\ldots\ldots M-1\}$, $y \in \{0,\ldots\ldots N-1\}$. The pattern is represented by a given template T of P x Q. A common way to calculate the position (i, j) of the pattern in the image I is to evaluate the normalized cross correlation value γ at each point (i, j) for I and the template T, which has been shifted by I steps in the x direction and by j steps in the y direction. Equation gives a basic definition for the normalized cross correlation coefficient [4].

$$\gamma(i,j)=\frac{\sum_{i=1}^{M}\sum_{j=1}^{N}[I(x,y)-\mu(I(x,y))]\bullet[T(x-i,y-i)-\mu(T)]}{\sqrt{\sum_{i=1}^{M}\sum_{j=1}^{N}[I(x,y)-\mu(I(i,j))]}\sqrt{\sum_{i=1}^{M}\sum_{j=1}^{N}[T(x-i,y-j)-\mu(T)]}} \quad (1)$$

$$\mu(I(x,y))=\frac{\sum_{x=i}^{i+P-1}\sum_{y=j}^{j+Q-1}I(x,y)}{P\times Q} \quad (2)$$

With similar notation μ(T) is the mean value of the template T. The denominator in Equation (1) is the variance of the zero mean value image function I(x, y) - μ(I(x, y) and the shifted zero mean template function T(x-i, y-j) - μ(T). Due to this normalization, γ (i, j) is independent to changes in brightness to contrast of the image, which are related t the mean value and the standard deviation.

C. *SUM OF ABSOLUTE DIFFERENCE (SAD) METHOD*

Sum of absolute differences (SAD) is a widely used as simple algorithm for measuring the similarity between image blocks. It works by taking the absolute difference between each pixel in the original block and the corresponding pixel in the block being used for comparison. These differences are summed to create a simple metric of block similarity. The sum of absolute differences may be used for a variety of purposes, such as object recognition, the generation of disparity maps for stereo images, and motion estimation for video compression [3].

PROPOSED METHOD

The measure used in this paper is the sum of absolute value of differences one: we give a faster algorithm to perform the basic template matching computation for this measure using the frequency domain. In this paper, we propose to expedite this naive approach using the FFT transform while exploiting the Fourier correlation theorem.

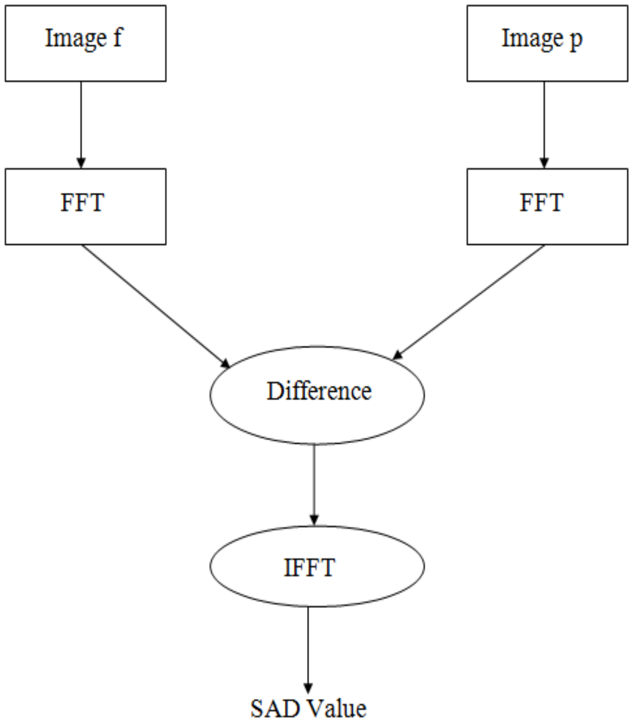

Fig. 2 Proposed algorithm of Sum of Absolute Difference (SAD) using FFT

II EXPERIMENTAL RESULT

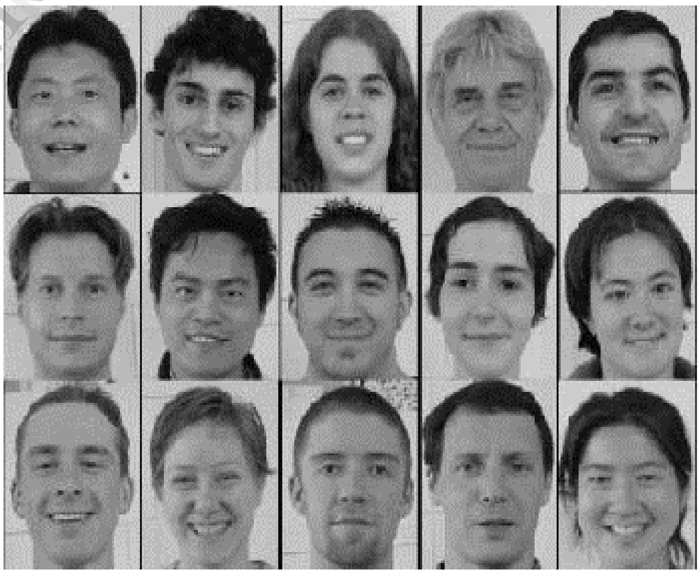

Fig. 3: Sample for the dataset of Image

TABLE 1 Result of The Original Image Match With The Template Image

Image	*Template Image*	*Normalized Cross Correlation (%)*	*Convolution (%)*	*Enhanced Sum of Absolute Difference (ESAD) (%)*
1		70.8560	63.2885	65.53
2		60.4207	73.6661	59.2465
3		36.7889	34.7366	44.2646
4		66.2081	66.6496	72.7173
5		59.3471	62.07	62.5865
6		82.6203	72.3577	78.9071
7		72.4517	78.8588	62.261
8		73.1622	68.2921	72.8487
9		66.7623	67.6781	69.2173
10		53.0195	53.702	60.979
11		57.1568	49.4729	71.8775
12		99.999	90.1407	100
13		53.6270	51.8441	68.4027
14		61.0301	63.5435	67.4977
15		69.4749	75.7408	68.8115

TABLE 2 Result of The Original Image Match with the Different Noise level

Image	*Template Image*	*Normalized Cross Correlation (%)*	*Convolution (%)*	*Enhanced Sum of Absolute Differenc (ESAD) (%)*
1	Noise level 0.02 	63.4500	48.9044	63.6862
2		54.1626	58.8944	57.2902
3		32.7851	40.5082	42.5719
4		61.8450	48.4054	70.9065
5		53.5855	33.4846	60.8617
6		75.3941	47.0841	76.7215
7		66.8403	56.936	60.6179
8		66.8001	40.2287	71.011
9		61.3848	45.2591	67.3781
10		47.3347	39.603	59.3413
11		53.4797	42.9207	69.7898
12		92.0831	45.0069	97.5308
13		49.0040	41.9301	66.4173
14		56.4253	41.5104	65.6663
15		63.6880	57.4282	66.8173

TABLE 3 Result of Blurring Template Image 1 with Original Image

Blurring Image	*Normalized Cross Correlation (NCC)*	*Convolution*	*Enhanced Sum of Absolute Difference (ESAD)*	*Sum of Absolute Difference (SAD)*
1x1	100	87.7672	100	100
2x2	94.6881	39.2029	91.3869	94.4827
3x3	95.8576	39.0438	92.9623	94.8471
4x4	92.0206	39.5053	87.9713	91.5062
5x5	90.5066	39.7647	86.3542	90.2046

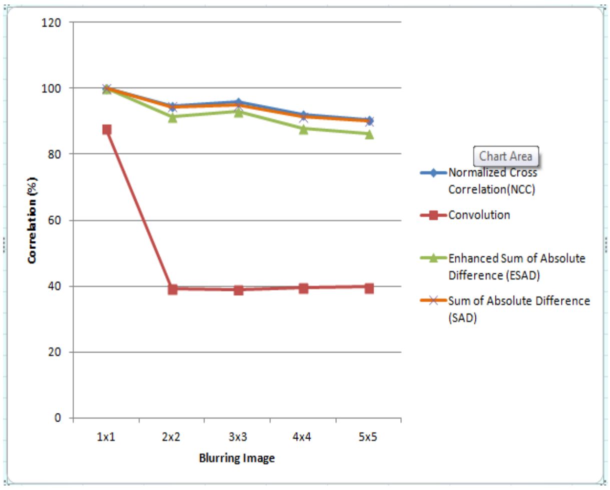

Fig. 4: Chart of Template Image 1

Blurring Image	*Normalized Cross Correlation (NCC)*	*Convolution*	*Enhanced Sum of Absolute Difference (ESAD)*	*Sum of Absolute Differen ce (SAD)*
1x1	100	57.638	100	100
2x2	96.879	57.648	91.914	94.6796
3x3	97.167	57.297	93.036	95.1000
4x4	95.005	57.293	88.671	92.0237
5x5	93.635	57.379	87.2	9.104

TABLE 4 Result of Blurring Template Image 2 with Original Image

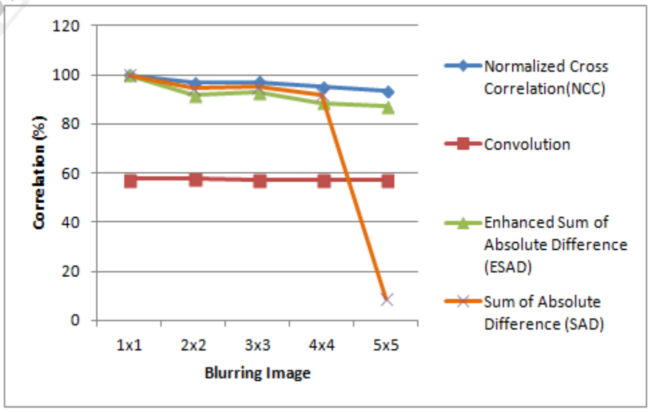

Fig.5: Chart of Template Image 2

TABLE 5 Result of Blurring Template Image 3 with Original Image

Blurring Image	*Normalized Cross Correlation(NCC)*	*Convolution*	*Enhanced Sum of Absolute Difference (ESAD)*	*Sum of Absolute Difference (SAD)*
1x1	100	60.829	100	100
2x2	95.903	61.225	90.975	94.5442
3x3	97.056	61.865	93.026	95.1021
4x4	94.29	62.593	88.21	92.0223
5x5	93.55	41.557	87.175	91.0373

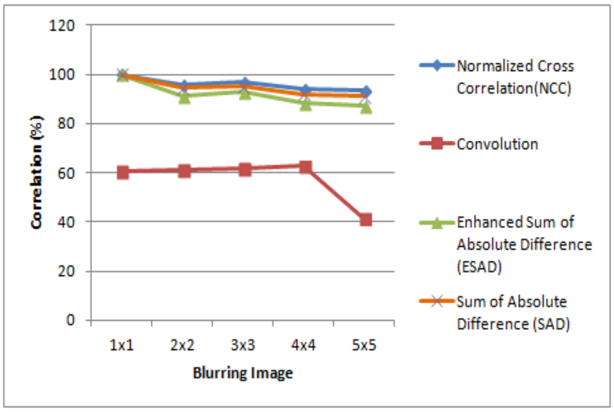

Fig 6: Chart of Template Image 3

TABLE 6 Result of Blurring Template Image 4 with Original Image

Blurring Image	*Normalized Cross Correlation(NCC)*	*Convolution*	*Enhanced Sum of Absolute Difference (ESAD)*	*Sum of Absolute Difference (SAD)*
1x1	100	45.58	100	100
2x2	96.038	45.904	90.541	94.5529
3x3	97.407	45.596	92.417	95.449
4x4	93.848	45.407	87.73	92.4202
5x5	92.325	45.08	86.064	91.3023

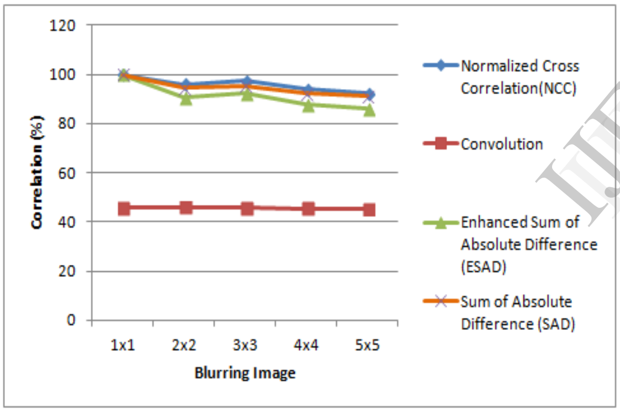

Fig 7: Chart of Template Image 4

TABLE 7 Result of Blurring Template Image 5 with Original Image

Blurring Image	*Normalized Cross Correlation(NCC)*	*Convolution*	*Enhanced Sum of Absolute Difference (ESAD)*	*Sum of Absolute Difference (SAD)*
1x1	100	46.87	100	100
2x2	90.604	46.827	91.607	95.2079
3x3	93.736	47.909	93.498	95.5471
4x4	86.811	48.075	88.732	92.7087
5x5	85.183	48.115	87.769	91.5948

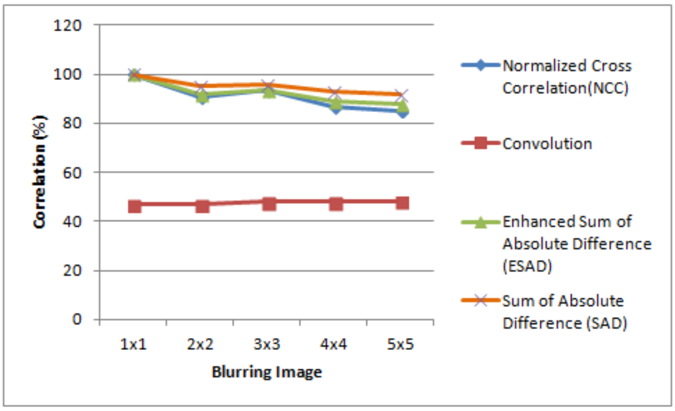

Fig 8: Chart of Template Image 5

The charts as shown in the above figure represent that by blurring image, the correlation of images reduces. The comparison among NCC, Convolution base and ESAD show that the correlation accuracy drastically reduces with respect to blurred images. Correlation for convolution remains almost constant and correlation for ESAD varies with blurred image. Hence E-SAD works properly for the images having less accuracy.

TABLE 8 Result of Noise Level Template Image 1 with Original Image

Noise level	*Normalized Cross Correlation(NCC)*	*Convolution*	*Enhanced Sum of Absolute Difference (ESAD)*	*Sum of Absolute Difference (SAD)*
0	100	38.693	100	100
0.2	56.148	33.89	74.317	86.1113
0.4	36.41	32.359	49.214	71.161
0.6	21.3	28.226	24.03	58.1798
0.8	10.914	25.838	0	43.9358
1	3.9639	23.781	0	28.9442

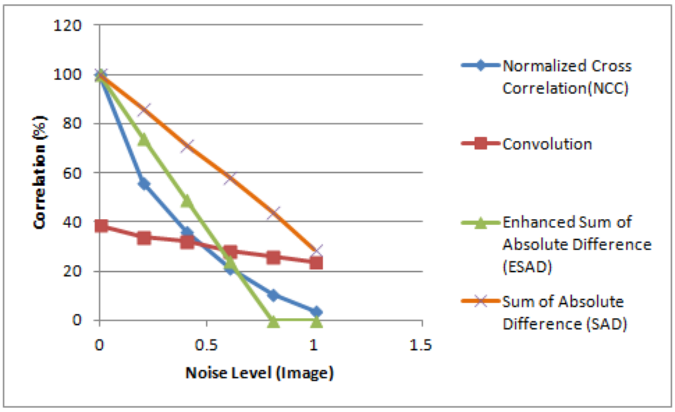

Fig. 9: Chart of the Template Image 1 for different noise level

TABLE 9 Result of Noise Level Template Image 2 with Original Image

Noise level	*Normalized Cross Correlation(NCC)*	*Convolution*	*Enhanced Sum of Absolute Difference (ESAD)*	*Sum of Absolute Difference (SAD)*
0	100	85.053	100	100
0.2	61.126	40.768	74.6	88.9685
0.4	36.524	36.965	47.778	77.0338
0.6	22.892	34.046	22.731	67.2171
0.8	11.849	30.906	0	53.8542
1	5.0795	28.545	0	43.3508

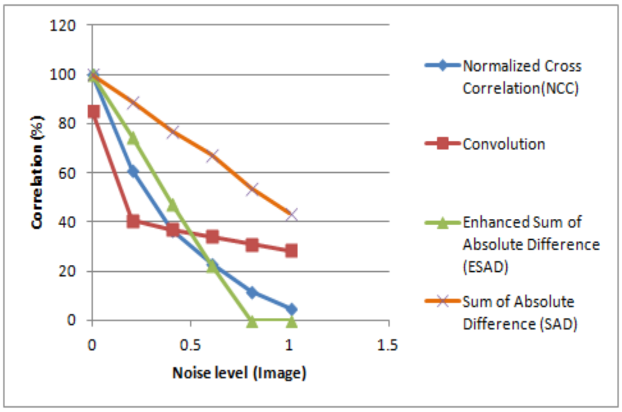

Fig. 10: Chart of the Template Image 2 for different noise level

TABLE 10 Result of Noise Level Template Image 4 with Original Image

Noise level	*Normalized Cross Correlation(NCC)*	*Convolutio n*	*Enhanced Sum of Absolute Difference (ESAD)*	*Sum of Absolute Differenc e (SAD)*
0	100	45.58	100	100
0.2	63.275	31.418	75.035	88.5779
0.4	38.981	26.959	48.722	97.9062
0.6	21.246	18.394	22.698	64.2587
0.8	10.159	24.096	0	52.9165
1	4.3442	18.138	0	42.9787

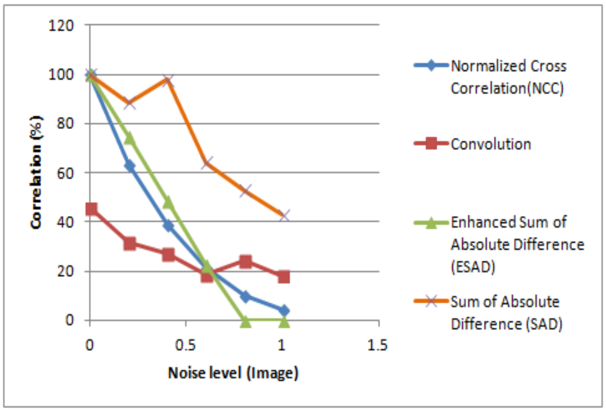

Fig. 11: Chart of the Template Image 3 for different noise level

TABLE 11 Result of Noise Level Template Image 4 with Original Image

Noise level	*Normalized Cross Correlation(NCC)*	*Convolution*	*Enhanced Sum of Absolute Difference (ESAD)*	*Sum of Absolute Difference (SAD)*
0	100	46.724	100	100
0.2	45.281	33.026	73.812	85.7656
0.4	27.412	31.138	48.541	70.3246
0.6	14.113	29.537	24.976	56.8212
0.8	7.9375	21.993	0	41.0825
1	5.0512	17.952	0	27.4662

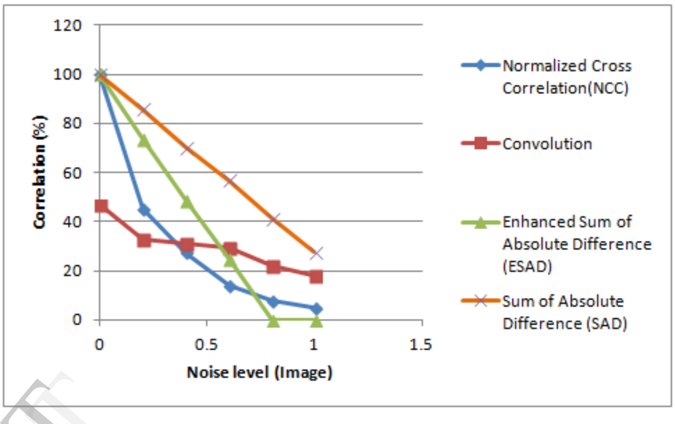

Fig. 12: Chart of the Template Image 4 for different noise level

TABLE 12 Result of Noise Level Template Image 4 with Original Image

Noise level	*Normalized Cross Correlation(N CC)*	*Convolution*	*Enhanced Sum of Absolute Difference (ESAD)*	*Sum of Absolute Difference (SAD)*
0	100	34.0809	100	100
0.2	56.1212	26.9102	75.3673	88.045
0.4	33.3689	22.8653	49.4115	77.2869
0.6	18.9207	19.6579	22.9208	62.5998
0.8	9.145	20.8433	0	52.026
1	5.4637	18.2268	0	40.8365

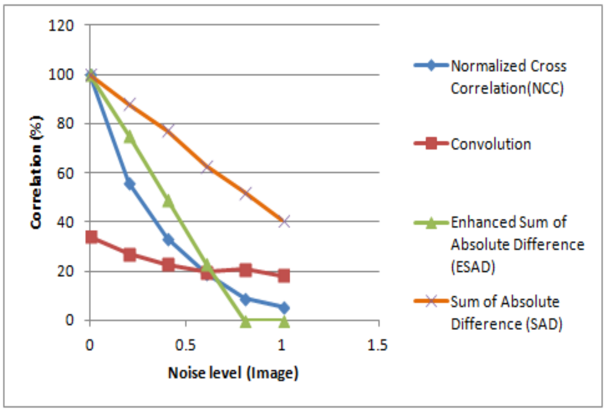

Fig. 13: Chart of the Template Image 2 for different noise level

As shown in the above figure 9, 10, 11, 12 and 13, we can interpret that after adding the different level noise in Normalized Cross Correlation method and Convolution method, correlation value decreases gradually. While there is a drastic change in Enhance sum of absolute difference method while adding different noise levels. Hence variation in image helps to differentiate the objects from the template.

CONCLUSION

In this paper authors have proposed a modified enhanced SAD technique (E-SAD) to improve the performance of SAD. Enhanced SAD proved superiority compared with the other similarity measurements like NCC and Convolution based techniques. Maximum accuracy achieved by E-SAD is 97.5% with noise level 0.02. Template can be restored even from the blurred images. This technique is sensitive to noise.

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