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A Comparative Study Between Moravec and Harris Corner Using Wavelet Based Image Fusion

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Abstract— ***In this paper a comparative study between Moravec and Harris Corner Detection for obtaining features which is required for tracking and recognizing objects from a fused image. Image fusion is a combination of information gathered from different images which is useful for extraction of more numbers of features from Multi-biometric systems, useful for the purpose of biometric recognition and identification. Image fusion is carried out using wavelet based alpha blending technique.***

***Keywords*— Image fusion, Alpha-Blending, Wavelet, Moravec , Harris Corner**

I. INTRODUCTION

A corner is a point for which there are two dominant and different edge directions in the vicinity of the point. In simpler terms, a corner can be defined as the intersection of two edges, where an edge is a sharp change in image brightness. Generally termed as interest point detection, corner detection is a methodology used within computer vision systems to obtain certain kinds of features from a given image. The initial operator concept of "points of interest" in an image, which could be used to locate matching regions in different images, was developed by Hans P. Moravec in 1977. The Moravec operator is considered to be a corner detector because it defines interest points as points where there are large intensity variations in all directions.

For humans, it is easier to identify a “corner”, but a mathematical detection is required in case of algorithms. Chris Harris and Mike Stephens in 1988 improved upon Moravec's corner detector by taking into account the differential of the corner score with respect to direction directly, instead of using shifted patches. Moravec only considered shifts in discrete 45 degree angles whereas Harris considered all directions. Harris detector has proved to be more accurate in distinguishing between edges and corners. He used a circular Gaussian window to reduce noise.

Wavelet Based alpha-blending image fusion technique generates a fused image. Harries Corner detection on fused image [1] gives an effective result for obtaining features, required to track and recognized objects. A multi-biometric system [2] helps to overcome the limitations of the uni-modal biometric systems in the field of biometric recognizing and identifying.

II. DISCRETE WAVELET TRANSFORMATION

The wavelet transform describes a multi-resolution decomposition process in terms of expansion of an image onto a set of wavelet basis functions. Discrete Wavelet Transformation has its own excellent space frequency localization property. Applying DWT in 2D images corresponds to 2D filter image processing in each dimension. The input image is divided into 4 non-overlapping multi-resolution sub-bands by the filters, namely LL1 (Approximation coefficients), LH1 (vertical details), HL1 (horizontal details) and HH1 (diagonal details). The sub-band (LL1) is processed further to obtain the next coarser scale of wavelet coefficients, until some final scale “N” is reached. When “N” is reached, we’ll have 3N+1 sub-bands consisting of the multi-resolution sub-bands (LLN) and (LHX), (HLX) and (HHX) where “X” ranges from 1 until “N”. Generally most of the Image energy is stored in these sub-bands.

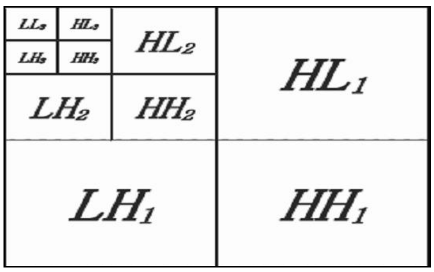


Fig.1 Three phase decomposition using DWT.

The Haar wavelet is also the simplest possible wavelet. Haar wavelet is not continuous, and therefore not differentiable. This property can, however, be an advantage for the analysis of signals with sudden transitions.

III. ALPHA-BLENDING TECHNIQUE

Alpha-Blending [2, 3] is the way of mixing of two images together to form a fused image. Alpha Blending is accomplished in computer graphics by blending each pixel from the first source image with the corresponding pixel in the second source image. Here's the equation for executing alpha blending

Final pixel = alpha * (First image's source pixel) + (1.0-alpha) * (Second image's source pixel)

The blending factor or percentage of colors from the first source image used in the blended image is called "alpha." The alpha used in algebra is in the range 0.0 to 1.0, instead of 0 to 100%.

According to the formula of the alpha blending the fussed image is given by

FI=alpha*(IM1) + (1.0-alpha)*(IM2) (1)

Where alpha is set as 0.5

RW=Recovered watermark, FI=fussed image, IM1= selected sub-band of the first image, IM2= selected corresponding sub-band of the second Image.

IV. MORAVEC CORNER DETECTION

Hans P. Moravec developed Moravec operator in 1977 for his research involving the navigation of the Stanford Cart [7,8] through a clustered environment. Since it defines interest points as points where there is a large intensity variation in every direction, which is the case at corners, the Moravec operator is considered a corner detector.

However, Moravec was not specifically interested in finding corners, just distinct regions in an image that could be used to register consecutive image frames.

The concept of "points of interest" as distinct regions in images was defined by him. It was concluded that in order to find matching regions in consecutive image frames, these interest points could be used. In determining the existence and location of objects in the vehicle's environment, this proved to be a vital low-level processing step.

Since the concept of a corner is not well-defined for gray scale images, many have commended this relaxation in the "definition" of “a corner”.

ALGORITHM

The Moravec corner detector is stated formally below:[9]

Denote the image intensity of a pixel at (x, y) by I(x, y).
Input: grayscale image, window size, threshold T
Output: map indicating position of each detected corner.

1. For each pixel (x, y) in the image calculate the intensity variation from a shift (u, v) as:

$$V_{u,v}(x,y)=\sum_{\forall a,b \text{ in the window}}\left(I(x+u+a,y+v+b)-I(x+a,y+b)\right)^2$$

where the shifts (u,v) considered are: (1,0),(1,1),(0,1),(-1,1),(-1,0),(-1,-1),(0,-1),(1,-1)

2. Construct the cornerness map by calculating the cornerness measure C(x, y) for each pixel (x, y):

$$C(x,y)=\min\left(V_{u,v}(x,y)\right)$$

3. Threshold the interest map by setting all C(x, y) below a threshold T to zero.

4. Perform non-maximal suppression to find local maxima.

All non-zero points remaining in the cornerness map are corners.

V. HARRIS CORNER DETECTION

Harris corner detector [5,6] is based on the local auto-correlation function of a signal which measures the local changes of the signal with patches shifted by a small amount in different directions. Given a shift (x, y) and a point the auto-correlation function is defined as

$$c(x,y)=\sum_W[I(x_i,y_i)-I(x_i+\Delta x,y_i+\Delta y)]^2 \quad \text{……. (2)}$$

Where I (x_i, y_i) represent the image function and (x_i, y_i) are the points in the window W centered on (x, y).

The shifted image is approximated by a Taylor expansion truncated to the first order terms

$$I(x_i+\Delta x,y_i+\Delta y)\approx\left[I(x_i,y_i)+\left[I_x(x_i,y_i)\;\; I_y(x_i,y_i)\right]\right]\begin{bmatrix}\Delta x\\ \Delta y\end{bmatrix} \quad \text{………… (3)}$$

where $I_x(x_i, y_i)$ and $I_y(x_i, y_i)$ indicate the partial derivatives in x and y respectively. With a filter like [-1, 0, 1] and [-1, 0, 1] ^{T}, the partial derivates can be calculated from the image by
Substituting (3) in (2).

$$c(x,y)=[\Delta x\quad \Delta y]\begin{bmatrix}\sum_W\left(I_x(x_i,y_i)\right)^2 & \sum_W I_x(x_i,y_i)\,I_y(x_i,y_i)\\ \sum_W I_x(x_i,y_i)\,I_y(x_i,y_i) & \sum_W\left(I_y(x_i,y_i)\right)^2\end{bmatrix}\begin{bmatrix}\Delta x\\ \Delta y\end{bmatrix}=[\Delta x\quad \Delta y]C(x,y)\begin{bmatrix}\Delta x\\ \Delta y\end{bmatrix}$$

C(x, y) the auto-correlation matrix which captures the intensity structure of the local neighbourhood.

Let α_1 and α_2 be the Eigen values of C(x, y), then we have 3 cases to consider:

1. Both Eigen values are small means uniform region (constant intensity).
2. Both eigen values are high means Interest point (corner)
3. One eigen value is high means contour(edge)

To find out the interest points, Characterize corner response H(x, y) by Eigen values of C(x, y).

- C(x, y) is symmetric and positive definite that is α_1 and α_2 are >0
- $\alpha_1 \alpha_2 = \det(C(x, y)) = AC - B^2$
    - $\alpha_1 + \alpha_2 = \text{trace}(C(x, y)) = A + C$
- Harris suggested: That the $H_{cornerResponse} = \alpha_1 \alpha_2 - 0.04(\alpha_1 + \alpha_2)^2$

Finally, it is needed to find out corner points as local maxima of the corner response.

VI. PROPOSED METHOD

Step 1. Two images of same size are read and 1-level wavelet decomposition performed for both images.

Step 2. Fused decomposed images using Alpha-Blending technique.

Step 3. Enhanced fused image.

Step 4. Moravec, Harris corner detection technique applied on the fused image respectively.

Step 5. Extracted corners saved as a feature point for tracking and recognizing objects in the database for matching.

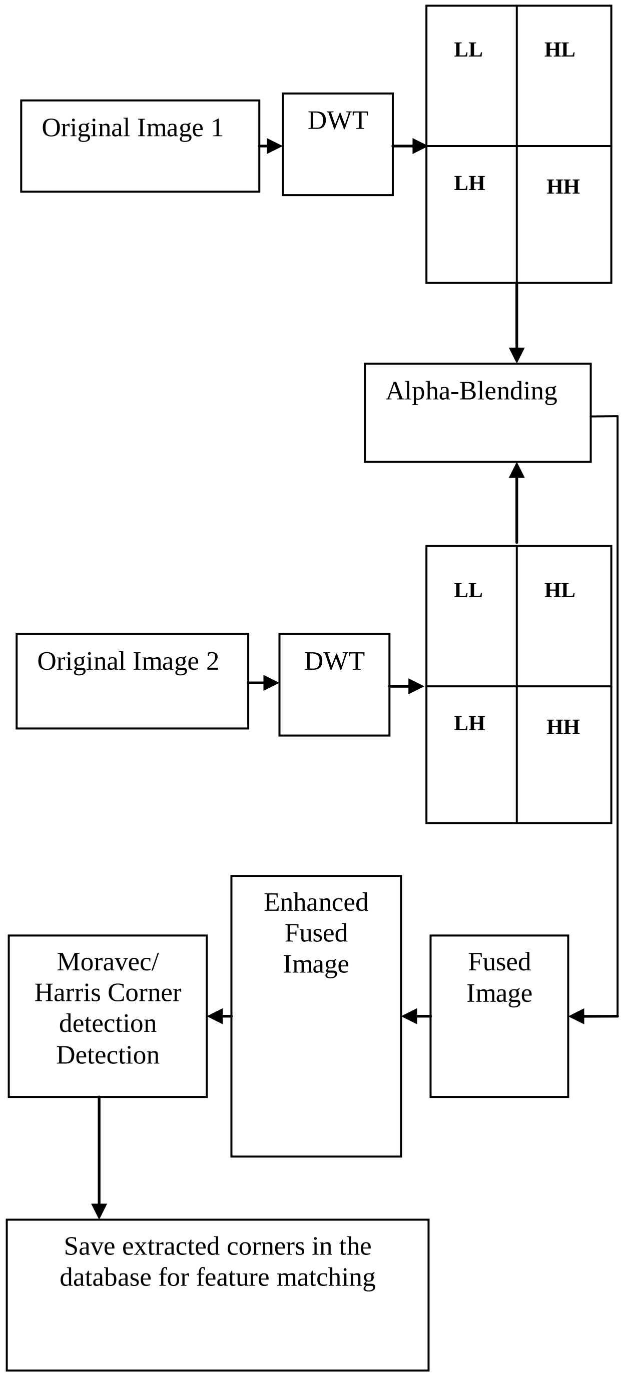
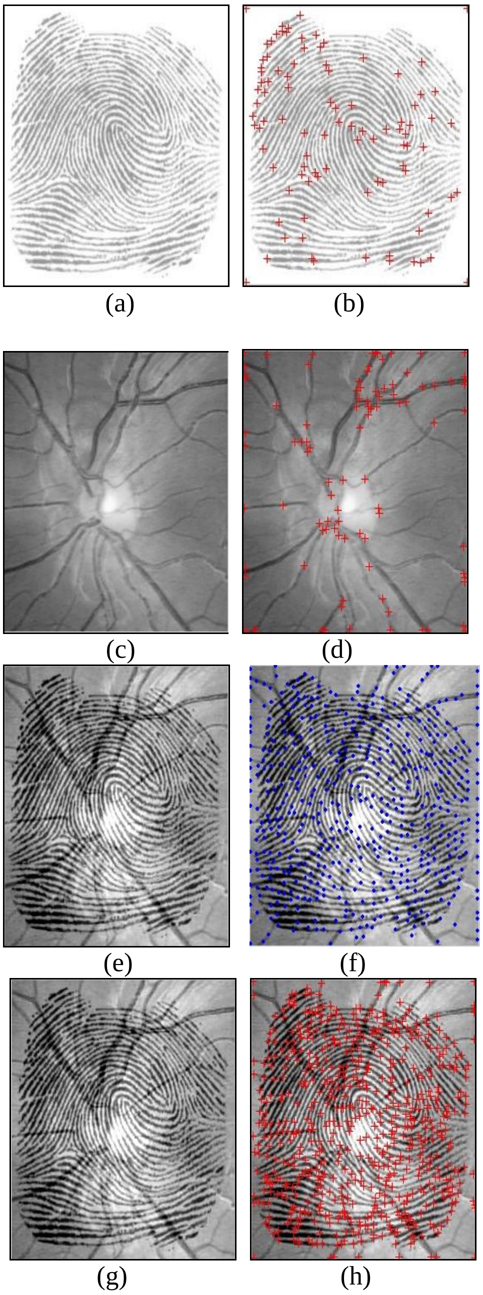


Fig. 2

VII. RESULT AND DISCUSSION



(a)Original Fingerprint (b) Harris Corner Detected Fingerprint image (c) Original Retina Blood Vessel (d) Harris Corner Detected Retina Blood Vessel (e) Fused Image (f) Moravec Corner Detected Fused Image (g) Fused Image (h) Harris Corner Detected Fused Image

Fig. 3 Extracted corners using proposed algorithm

TABLE I

Type	Number of corners found
Harris Corner Detected Fingerprint image	95
Harris Corner Detected Retina Blood Vessel	94
Moravec Corner Detected Fused Image	597
Harris Corner Detected Fused Image	503

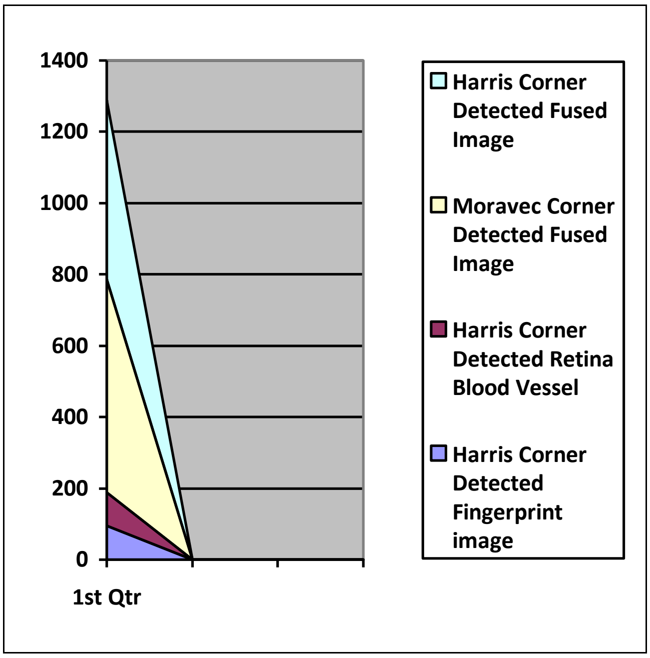


Fig. 4 Graphical representation of extracted corners using proposed algorithm

VIII. CONCLUSIONS

Corner Detected applied on pre-processed fused image using wavelet decomposition gives a very effective result. We tried to compare the performance of different existing corner detection algorithm on fused image for feature point extraction. The number of corner detected are stored in a database, use for future image processing operations like tracking or recognition of objects.

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