Advances in Computational Sciences and Technology
ISSN 0973-6107 Volume 12, Number 1 (2019) pp. 7-21

http://www.ripublication.com

Biometric Iris Recognition System Using Edge Detection and Gabor Filter for High Security

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Abstract

The iris recognition theme particularly consists of iris segmentation, normalization, function extraction, and matching. The function extraction plays a totally essential function in iris reputation device. This paper is provided the rotationally invariant iris texture feature extraction approach which makes use of the DWT and DT-CWT jointly. The proposed technique divides the normalized iris photo into six sub-areas and the combined rework is applied one at a time on each location to capture the statistics in 9 guidelines. The rotation invariant function vector is shaped via estimating the energies and widespread deviation of each sub-band. The Euclidean distance is used to match the feature vectors of template and take a look at iris images.

Keywords: Iris, pupil, edge detection, Gabor filters, DWT (Discrete Wavelet Transform), CWT (continuous Wavelet Transform)

INTRODUCTION

Biometric authentication is an automatic method for verifying an man or woman. The authentication is primarily based at the physiological or behavioral traits of human being. Amongst numerous biometric strategies including (fingerprint, signature, face, palm-print, palm-vein, iris and so forth.) iris is discovered to be the most reliable and accurate trait for excessive secured programs. it is due to the fact iris is unique, solid, and non-invasive.

Iris recognition is the system of figuring out an individual through studying its iris pattern. The iris is a muscle within the attention that regulates the scale of the student. it's miles the colored part of the attention with coloring based totally on the pigmentation inside the muscle. The basic block diagram of iris recognition system is shown in Fig.1. The whole system consists of segmentation, normalization, characteristic extraction, and matching.

The segmentation is the separation of iris from an eye fixed photo. In 1993, Daughman [1] pioneer of iris reputation gadget advanced an integro-differential operator to localize the inner and outer barriers of the iris. In Wildes [2], first the photo depth facts transformed into binary facet map, after which area factors vote to instantiate the unique contour parameter values. the edge map is recovered via gradient based totally side detection with the circular Hough transform. Li Ma et. al. [3], [4] first mission the photograph inside the vertical and horizontal instructions to approximately estimate the center co- ordinates of the pupil. The center co-ordinates of the iris are anticipated with the help of threshold. The canny side detector and Hough transform are then used to calculate the parameters of the iris. The normalization is used to simplify the similarly processing. The function extraction is the heart of the iris recognition gadget which extracts the functions from normalized iris image. The function extraction generally classified into 3 main classes-segments based totally approach,Zero-crossing detection and texture based method. The Gabor wavelet, Log-Gabor wavelet are used to extract the segment statistics proposed by means of Daughman [1], Meng and Xu [5], L. Masek [6], Proenca and Alexandre [7], M. Vatsa et. al. [8]. Boles and Boshash [9], Sanchez–avilla [10] used the DWT to compute the 0-crossing illustration at special resolutions of concentric circles. Wildes [2] proposed the characterization of iris texture thru Laplacian Pyramid with four distinctive resolutions. Many researchers extracted the feel capabilities the use of bank of spatial clear out [3], Haar [11]. The Hamming Distance, Euclidean, weighted Euclidean Distance, and signal correlation are used for the matching reason. The detailed literature on iris recognition can be discovered.

An iris-primarily based biometric identification scheme entails reading functions which can be found in the tissues that surrounds the student. Complicated iris patterns can contain many one-of-a-kind functions consisting of ridges, crypts, earrings, and freckles[1]. Iris scanning uses a reasonably conventional digital camera and calls for no close contact between the subject and the reader. The iris is particular from character to character because there are so many special styles that surround the pupil. The iris-scanning manner is straightforward and painless. Iris popularity is a demonstrated, correct way to discover humans. It examines computerized iris popularity as a biometrically primarily based technology for non-public identification and verification. Iris popularity gadget consists of the pre-processing machine, segmentation, characteristic extraction and recognition. Compared with other biometric capabilities, iris can gain high accuracy because of the wealthy texture of iris patterns. The overall performance of iris reputation system extraordinarily depends on segmentation. Maximum business iris reputation systems use patented algorithms evolved with the aid of Daugman, and those algorithms are capable of produce best popularity prices [2]. The Canny edge Detector is one of the maximum normally used picture processing equipment, detecting edges in a totally robust way [3]. This paper offers an technique for segmenting the iris styles. The used technique determines an automatic international threshold and the pupil middle. Experiments are achieved the use of iris photographs obtained from CASIA database (Institute of Automation, Chinese language Academy of Sciences) and application for its clean and green equipment in image manipulation. The system is to be composed of a number of sub-systems, which correspond to each degree of iris recognition. these ranges are segmentation – finding the iris vicinity in a watch photograph, normalization – growing a dimensionally regular illustration of the iris vicinity, and feature encoding – developing a template containing best the maximum discriminating features of the iris. The input to the system can be an eye photograph, and the output can be an iris template, with the intention to provide a mathematical representation of the iris vicinity. Performance analysis parameters used for proposed device are Computational time, false reputation rate, fake Rejection charge and Accuracy. Overall performance parameters are evaluated among two iris reputation methods. We examine the accuracy among the proposed system and Wavelet transform method. All photographs tested on this assignment have been taken from the Chinese Academy of Sciences Institute of Automation (CASIA) iris database. In sensible application of a potential system, an photo of the eye to be analyzed need to be received first in digital shape appropriate for evaluation [4].

IMAGE PREPROCESSING

Iris Preprocessing

Image enhancement is the process of adjusting digital image so that the results are most suitable for display. It is used to improve the quality of the image. The **Adaptive Mean Adjustment**[2] is used to enhance the image.Adaptive Mean Adjustment[2] is a computer image processing technique used to improve contrast in images. It modifies the allocation of the pixels to become more consistently increase out more than the obtainable pixel variety. In histogram dealing out, a histogram displays the sharing of the pixel intensity values. Dark image will have low pixel values whereas a bright image will have high pixel values.

Figure 2: Canny edge detection

CLAHE[2] formula is given by,

CLAHE = X(I,j)-Xmin(I,j)/Xmax(I,j)- Xmin(I,j) (1)

Where ,X is the image,Xmin-Minima of the image,Xmax-maxima of the image.

The main aim of the image enhancement is to improve the contrast and brightness of the image in order to improve the quality of the image.

The image is considered as a function z=f(x,y), it is an 2D matrix.

Where z is the gray level of the image.

f(x,y) = a1*x +a2*y + a3 +e(x,y), (2)

Calculate the values a1, a2, a3, i.e. $\hat{a}1$, $\hat{a}2$, $\hat{a}3$,

We have to reduce the sum of square of residuals at each pixel,

$$S^2 = \sum_x \sum_y [\hat{a}1 * x + \hat{a}2 * y + \hat{a}3 - f(x,y)]^2, \tag{3}$$

It gives

$\hat{a}1$, $\hat{a}2$, $\hat{a}3$ by

$$\hat{a}1 = \frac{\sum_x \sum_y x * f(x,y)}{\sum_x \sum_y x^2}, \quad \hat{a}2 = \frac{\sum_x \sum_y y * f(x,y)}{\sum_x \sum_y y^2}, \quad \hat{a}3 = \frac{\sum_x \sum_y f(x,y)}{\sum_x \sum_y 1}. \tag{4}$$

Thus,

F has an F distribution with 2,n-3 degree of freedom.

When considering 3*3 window, n-3= 6.

Now we derive the following. Change f(x,y) by equation (2) , Ie).,

a1*x +a2*y + a3 + e(x,y) , $\hat{a}1 = a1 + \frac{\sum_x \sum_y x * e(x,y)}{\sum_x \sum_y x^2}$,

$$\hat{a}2 = a2 + \frac{\sum_x \sum_y y * e(x,y)}{\sum_x \sum_y y^2}, \quad \hat{a}3 = a3 + \frac{\sum_x \sum_y e(x,y)}{\sum_x \sum_y 1}. \tag{6}$$

From above equation and noise equation, it drives variances of $\hat{a}1$, $\hat{a}2$, $\hat{a}3$

$$\sigma^2_{\hat{a}1} = \frac{\sigma^2}{\sum_x \sum_y x^2,} \quad \sigma^2_{\hat{a}2} = \frac{\sigma^2}{\sum_x \sum_y x^2,} \quad \sigma^2_{\hat{a}3} = \frac{\sigma^2}{\sum_x \sum_y x^2,} \tag{7}$$

the covariance is 0, nN

Now noises are un-correlated for pixels.

From equations (2) (4) (6):

$$S^2 = \sum_x \sum_y e^2(x,y) - (\hat{a}1 - a1)^2 \sum_x \sum_y x^2 - (\hat{a}2 - a2)^2 \sum_x \sum_y y^2 - (\hat{a}3 - a3)^2 \sum_x \sum_y 1. \tag{8}$$

Now e(x,y) ~ N(0),

$$\frac{\sum_x \sum_y e^2(x,y)}{\sigma^2} \sim \chi^2_{\mathrm{n}}, \tag{9}$$

The χ^2_{n} → for the chi-squared distribution with

$$\mathrm{F} = \frac{[(\hat{\mathrm{a}}1 - \mathrm{a}1)^2 \sum_{\mathrm{x}} \sum_{\mathrm{y}} \mathrm{x}^2 + (\hat{\mathrm{a}}2 - \mathrm{a}2)^2 \sum_{\mathrm{x}} \sum_{\mathrm{y}} \mathrm{y}^2]/2}{\mathrm{S}^2/(\mathrm{n}-3)}$$

n degrees of freedom, n can be calculated as,

$$\mathrm{n} = \sum_x \sum_y 1. \tag{10}$$

Because e(x,y) is a normal distribution function, based on the equation (6), $\hat{a}1$, $\hat{a}2$, $\hat{a}3$ gives the normal distribution :

$$\hat{a}1 \sim \mathrm{N}(\mathrm{a1}, \sigma^2_{\hat{a}1}), \hat{a}2 \sim \mathrm{N}(\mathrm{a2}, \sigma^2_{\hat{a}2}), \hat{a}3 \sim \mathrm{N}(\mathrm{a3}, \sigma^2_{\hat{a}3}), \tag{11}$$

with the variance given in equation (23), so

$$\frac{(\hat{a}1-a1)^2}{\sigma^2_{\hat{a}1}} = \frac{(\hat{a}1-a1)^2\sum_x\sum_y x^2}{\sigma^2} \sim \chi^2_1, \quad \frac{(\hat{a}2-a2)^2}{\sigma^2_{\hat{a}2}} = \frac{(\hat{a}2-a2)^2\sum_x\sum_y y^2}{\sigma^2} \sim \chi^2_1,$$

$$\frac{(\hat{a}3-a3)^2}{\sigma^2_{\hat{a}1}} = \frac{(\hat{a}3-a3)^2\sum_x\sum_y 1}{\sigma^2} \sim \chi^2_1. \tag{12}$$

Following the equations (9), (10), (12) ,

$$\frac{S^2}{\sigma^2} \sim \chi^2_{(n\text{-}3)}, \tag{13}$$

U~ χ^2_j , V ~ χ^2_k , then

$$\frac{U/j}{V/k} \sim F_{j,k.}$$

$$\frac{[(\hat{a}1-a1)^2\sum_x\sum_y x^2 + (\hat{a}2-a2)^2\sum_x\sum_y y^2]/2}{S^2/(n-3)} \sim F_{2,n\text{-}3.} \tag{14}$$

DN (Digital number)

Estimate the Digital Number (DN) as

DN = WF * RV + (1-WF) * DN(old), (15)

RV - > Reference value for the pixels

WF - > Weight vector

WF = max (WF1, WF2) (16)

The contrast of the image is calculated as follows,

(Image contrast enhancement)

$$WCON = \frac{DN\max(window) - DN\min(window)}{DN\max(image) - DN\min(image)} \tag{17}$$

Iris Localization

Due to computational ease, the image became scaled down via 60%. The picture became filtered the usage of Gaussian clear out, which blurs the image and reduces outcomes because of noise. The diploma of smoothening is determined by using the same old deviation, σ and it is taken to be 2 in this example.

The part of the attention sporting data is handiest the iris part. It lies among the sclera and the student. Consequently the subsequent step is isolating the iris component from the eye image. The iris internal and outer barriers are positioned with the aid of locating the brink picture the use of the canny facet detector.

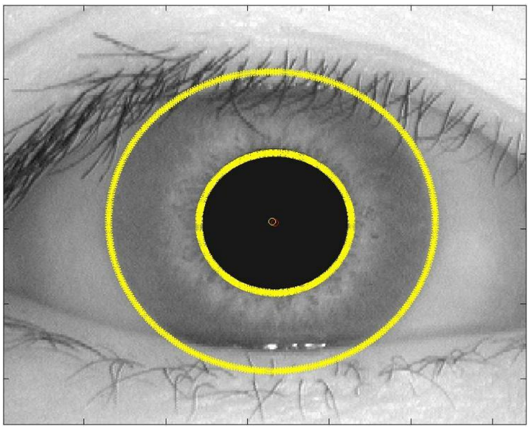


Figure 3: Image with boundaries

The Canny detector mainly entails 3 steps, viz. finding the gradient, non-most suppression and the hysteresis thresholding. As proposed by means of Wildes, the thresholding for the attention picture is finished in a vertical path

Simplest, in order that the have an impact on due to the eyelids can be reduced. This reduces the pixels at the circle boundary, however with using Hough rework, successful localization of the boundary can be received even with the absence of few pixels. it's also computationally quicker since the boundary pixels are lesser for calculation.

The use of the gradient picture, the peaks are localized the use of non-maximum suppression. it really works inside the following manner. For a pixel imgrad(x,y), within the gradient image, and given the orientation theta(x,y), the brink intersects two of its eight related buddies. The factor at (x,y) is a maximum if its cost is not smaller than the values at the 2 intersection points.

The subsequent step, hysteresis thresholding, gets rid of the vulnerable edges underneath a low threshold, but not if they may be connected to a edge above a excessive threshold thru a series of pixels all above the low threshold. In other words, the pixels above a threshold T1 are separated. Then, those factors are marked as side factors most effective if all its surrounding pixels are extra than some other threshold T2. the brink values were found by way of trail and blunders, and have been obtained as zero.2 and 0.19. Area detection is accompanied via finding the limits of the iris and the pupil. Daugman proposed the use of the Integra-differential operator to stumble on the bounds and the radii. This behaves as a circular side detector by means of searching the gradient image alongside the boundary of circles of growing radii. From the probability of all circles, the maximum sum is calculated and is used to discover the circle facilities and radii.

The Hough remodel is some other way of detecting the parameters of geometric items, and in this case, has been used to find the circles inside the part image. For each part pixel, the points at the circles surrounding it at extraordinary radii are taken, and their weights are expanded if they're edge factors too, and these weights are introduced to the accumulator array. Thus, in any case radii and area pixels were searched; the most from the accumulator array is used to locate the center of the circle and its radius. The Hough remodel is carried out for the iris outer boundary using the whole image, and then is performed for the scholar simplest, instead of the entire eye, due to the fact the student is usually in the iris.

There are a few issues with the Hough transform. First of all, the brink values are to be discovered by trial. Secondly, it is computationally intensive. This is improved by means of just having 8-manner symmetric factors at the circle for every search factor and radius. The eyelashes have been separated through thresholding, and people pixels have been marked as noisy pixels, considering they do no longer include within the iris.

Iris Normalization

As soon as the iris place is segmented, the next degree is to normalize this component, to allow technology of the iris and their comparisons. By Considering the fact that versions in the attention, like optical size of the iris, position of student within the iris, and the iris orientation trade man or woman to individual, it's far required to normalize the iris photograph, so that the representation is not unusual to all, with comparable dimensions. Normalization manner involves un-wrapping the iris and changing it into its polar equal. It’s far done the use of Daugman’s Rubber sheet model. The center of the pupil is considered as the reference point and a remapping formula is used to transform the points on the Cartesian scale to the polar scale.

Given M_I ,mean of edge detected image $I(i,\ j)$, binary image $I'(i,\ j)$ is computed by the following equation .

$$I'(i,\ j) = \begin{cases} 0, & I(i,j) \le T_B \\ 255, & others \end{cases} \tag{2}$$

where, $T_B = M_I * P_B / 100$

-1	-2	-1
0	8	0
-1	-2	-1

Fig-2. 3*3 mask used in edge detection

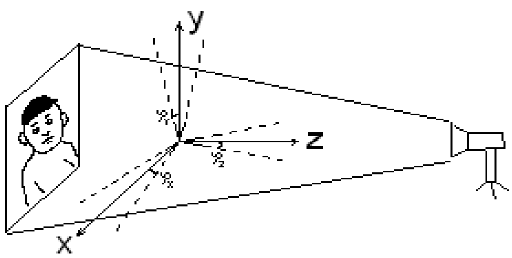


Fig-3, camera-face inerface condition in our system where,

$$\left.\begin{aligned} 0^{\circ} \le \varphi_x, \varphi_y, \varphi_z \le 15^{\circ} \\ 0.3m \le l_z \le 0.7m \end{aligned}\right\} \qquad (3)$$

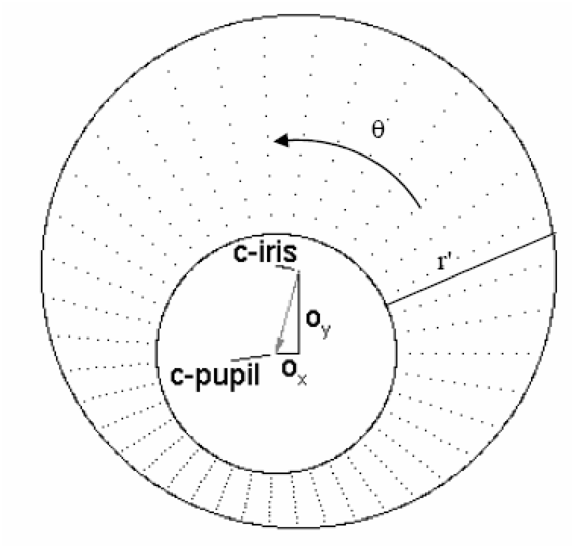


Figure 4: Normalization process

Figure 6: Normalized iris image

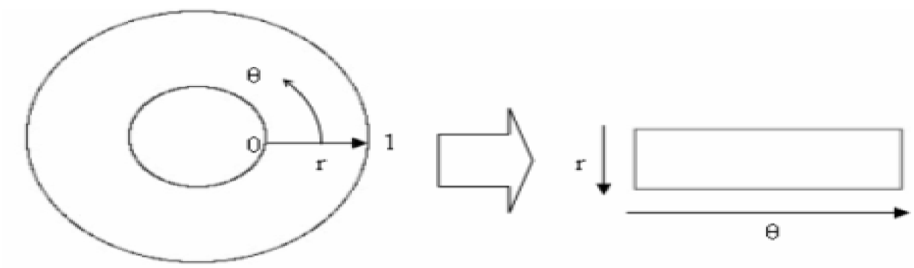


Figure 5: Un-wrapping the iris

Encoding

The final technique is the generation of the iris. For this, the maximum discriminating feature in the iris pattern is extracted. The phase facts inside the pattern handiest is used because the segment angles are assigned irrespective of the photograph comparison. Amplitude records are not used since it depends on extraneous elements. Extraction of the segment information, in line with Daugman, is carried out the use of second Gabor wavelets. It determines which quadrant the resulting pharos lies the use of the wavelet:

$$h_{\{Re,Im\}} = \mathrm{sgn}_{\{Re,Im\}} \int_{\rho} \int_{\phi} I(\rho,\phi) e^{-i\omega(\theta_0-\phi)} \cdot e^{-(r_0-\rho)^2/\alpha^2} e^{-(\theta_0-\phi)^2/\beta^2} \rho d\rho d\phi$$

where, $h_{\{Re,Im\}}$ has the actual and imaginary part, every having the fee 1 or 0, depending on which quadrant it lies in.

A simpler manner of using the Gabor filter out is via breaking up the 2nd normalized pattern into some of 1D wavelets, and then those indicators are convolved with 1D Gabor wavelets.

Gabor filters are used to extract localized frequency records. However, due to some of its barriers, log-Gabor filters are extra broadly used for coding natural photographs. It become suggested by discipline, that the log filters (which use Gaussian transfer features regarded on a logarithmic scale) can code herbal pix higher than Gabor filters (viewed on a linear scale). Information of herbal iris implies the presence of high-frequency additives. Because the regular Gabor filters beneath-represent high frequency additives, the log filters grow to be a better desire. Log Gabor filters are constructed using

$$G(f) = \exp\left(\frac{-(\log(f/f_0))^2}{2(\log(\sigma/f_0))^2} \right)$$

For the reason that strives at enforcing this characteristic become unsuccessful, the gabor- convolve function written by using Peter Kovesi was used. It outputs a cellular containing the complex valued convolution consequences, of the same length as the enter image.

Wavelet Transform

In sub-band coding, an image is decomposed into a hard and fast of band limited components, known as sub-bands, which may be reassembled to reconstruct the authentic image without blunders. Figure 1 suggests the components of two-band sub-band coding and deciphering system. For the reason that bandwidth of the ensuing sub-bands or is smaller than the authentic sign x(n), the sub-bands may be down-sampled without lack of facts. Reconstruction of the original signal is completed by using up-sampling, filtering, and summing the individual sub-bands.

Let $\phi(x)$ be some mother function. The $\phi(2x)$ is the same function compressed by a factor of 2. Binary compression can therefore be denoted as $\phi_j = \phi(2^j x)$. Likewise $\phi(2x-1)$ is our compressed function translated by 1. Multiple translation and compression of the mother function can therefore be denoted as

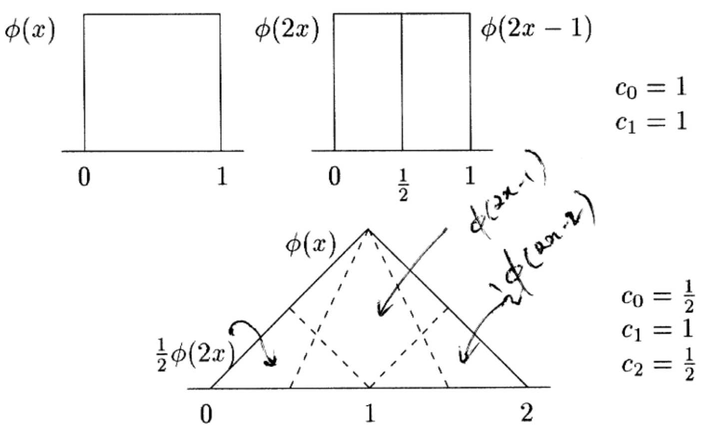
$$\phi_{jk} = \phi(2^j x - k)$$

We do ***not*** choose $\phi(x)$ arbitrarily but impose two conditions.

1) $\phi(x) = \sum_k c_k \phi(2x-k)$ or more generally $\phi(2^{j-1}x) = \sum_k c_k^j \phi(2^j x - k)$. That is it lends itself to a fractal like summing behaviour.

2) $\int \phi(x)dx = 1$, the normalisation condition. This leads to $\sum_k c_k = 2$. Alas, life is not easy and there is much confusion in the literature at this point. If you accept this as is then you will **NOT** get coefficients which produce a reversible transform. Since this is desirable in physics we need to do what Numerical Recipes suggests and force $\sum_k c_k^2 = 1$. This means reducing the coefficients by a further factor $1/\sqrt{2}$. The reason lies buried deep in matrix inversion.

- Here are two examples, our friend Haar and the "top hat"



- Again a $1/\sqrt{2}$ multiplication factor ensures reversibility of the transform

- Ingrid Daubechies invented a four coefficient fractal which is not a simple mother function shape as above, but instead must be constructed by working backwards from the coefficients. They are:

$$c_0 = \tfrac{1}{4}(1+\sqrt{3}), c_1 = \tfrac{1}{4}(3+\sqrt{3}), c_2 = \tfrac{1}{4}(3-\sqrt{3}), c_3 = \tfrac{1}{4}(1-\sqrt{3})$$

Again "Numerical Recipes" surreptitiously adds a further $1/\sqrt{2}$ and with good reason.

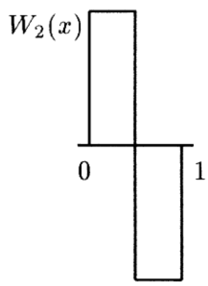
- From the mother or scaling function and the coefficients we construct wavelet functions $\psi(x)$.

  $\psi(x) = \sum_k (-1)^k c_{M-k} \phi(2x-k)$ or at other compression levels $\psi(2^{j-1}x) = \sum_k (-1)^k c_{M-k} \phi(2^j x - k)$ with generally $\psi_{jk} = \sum_k (-1)^k c_{M-k} \phi(2^j x - k)$

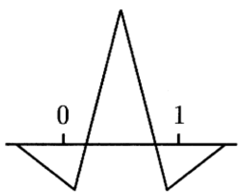
  Three things to note:

  1) The introduction of an alternating negative sign on the coefficients.
  2) The inversion of the order of coefficients assuming there are M coefficients.
  3) If you have multiplied by the requisite fudge factor to get a reversible transform you don't need to do any more on these coefficients.

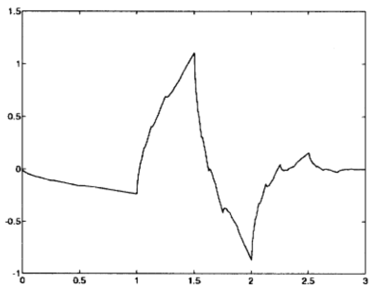
- Here are the basic wavelet shapes at the highest level. The Daubechies wavelet is a construction.



Haar wavelet from box function
$W_2(x) = \phi(2x) - \phi(2x-1)$



"Wavelet" from hat function
$W = \phi(2x) - \frac{1}{2}\phi(2x-1) - \frac{1}{2}\phi(2x+1)$



$W_4(x)$ from $\phi = D_4$ Orthogonal wavelet

Please note the wavelet function for the top hat is strictly $\psi(x) = \frac{1}{2}\phi(2x) - \phi(2x-1) + \frac{1}{2}\phi(2x-2)$ and inverted to the above diagram. The areas sum to zero as does the sum of the coefficients.

Edge detection

For multi scale aspect detection for accurate segmentation, meaning extracting items from heritage, we want accurate detection of item barriers. The conventional aspect detection set of rules indicates all the edges, which can be outside and inside the item in addition to noise within the photograph not exactly of item boundaries. However from the filtered output if we get an side the usage of canny area detector it'll show the decreased wide variety of edges, which we wanted for our boundary detection. The input for this filter is taken from the vector records, which turned into calculated using EGVF. From the gradient vector price the importance and the perspective could be calculated.

Magnitude = sqrt(U^2+V^2)

The iris filter out radius has been set as three to five. because the clear out mask has built handiest primarily based at the radius(R *2 +1).If the radius will increase then the processing time also will increase that's shown in desk 2. the use of the kernel approaches the image. we have used the Irisfilter for the detection of approximately rounded convex regions. performance does no longer depend on the comparison; for that reason, opacities with very weak evaluation may be stronger sincerely.

The sum of cosine of differences of angles (angles between the line connecting starting place and the gradient vector of each factor) might be early same to 1 if it is a item vicinity, it is going to be close to to 0 or if it'll no longer be a object area. item and non-item pixels may be diagnosed as neighborhood low-density areas on the image. Their absolute values, however, aren't constant and they vary in size, history versions, imaging situations, and so on.

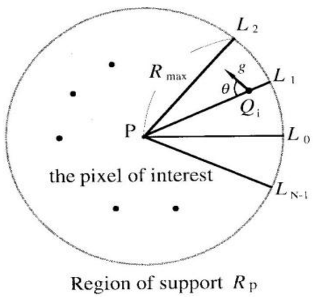


Fig 6 Iris filter kernel process

Table 3. Time comparison based on Filter Kernel size

Filtering time based on size of the image

Type	Image	Size	Time (sec)
Natural	Parrots.jpg	600×900	14
Natural	Cubbie.jpg	600×800	11
Test	Coins.png	246×300	1.5
Test	Rice.png	256×256	1.4

CONCLUSION

In this paper, we've got offered an powerful method for iris function extraction. This technique is based upon the decomposition of an iris photo the use of DWT (db3) and DT-CWT jointly which extracts the facts in nine orientations with the introduction of restricted computational complexity. Moreover, the proposed method divides the photo into six sub-pictures and derives the nearby features separately from each place. The experimental analysis illustrates that counseled technique decreased the ways and FRR by means of 80 respectively database respectively in database in opposition to worldwide functions. It’s also determined that proposed method slightly improved the overall performance over the person transforms. The proposed method is scale, translational, and rotational invariant and additionally plays inside the presence of noise as we have no longer taken into consideration any noise elimination method at some stage in the segmentation of an iris. it's also determined that the computational complexity of the proposed approach is 5 times less than the Gabor remodel which suits higher for the real time applications. For destiny work, it's far essential to eliminate the HH sub-band of DWT from DWT+DT-CWT to conquer the redundancy and captures the statistics in quantity of instructions in order to enhance the a ways and particularly FRR.

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