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Image Registration for Area Matching by Using Transform Based Methods

Nayana M. Nichat *
Information Technology,
Sipna College of Engineering and Technology
SGBAmravati university,India.

Prof. V.K. Shandilya
computer science engineering,
Sipna College of Engineering and Technology,
SGBAmravati university, India.

Abstract— Image registration is a process of finding a transformation that maps one image of object onto another image of same or similar object by optimizing certain criterion. With the increase in the number of images collected every day registration of multi-sensor/multi-spectral images has become an important issue. This paper implements image registration technique based on different transforms. These image registration techniques can be used to locate the object in one image onto another image. It tries to find out the object or an area of unregistered image by comparing it with the reference image and locate that object or area of interest in reference image. The similarity measure is used to locate the similar object or area into the reference image. The proposed technique uses HAAR and WALSH transform for the transformation. This paper uses HAAR and WALSH transformation for comparison between results obtained by these two transforms and the Root Mean Square Error (RMSE) is used as similarity measures. Experimental result shows that, the proposed technique work successfully.

Keywords— Image Registration, area of interest, Root Mean Square Error (RMSE), HAAR Transform, WALSH Transform

I. INTRODUCTION

Image registration is one of the most important tasks when integrating and analysing information from various sources. Image registration is the process of geometrically aligning one image to another image of the same scene taken from different viewpoints or by different sensors. It is the process of transforming different sets of data into one coordinate system. In this paper image registration process tries to determine the most accurate match between the images. The proposed technique tries to find out the object or area in the input template onto the reference image. For implementing this image registration technique, it includes transform base methods and similarity measures. A linear image transform expresses an image as a weighted sum of basic functions. [1] The registration technique uses Walsh and Haar transform. The Walsh and Haar transform are examples of orthogonal transforms. It has orthogonal basis functions and therefore has the same number of transform coefficients as pixels, and has good localization in space and spatial frequency. Such transforms is useful for a variety of image processing tasks [1]. The similarity metrics can used to measure the correspondence between images (or regions). Common examples of image similarity measures include Mean Squares, Normalized Correlation, and Mutual Information [2] etc.

From an operational view, the inputs of registration are the two views or two images to be registered and the output is a geometrical transformation, which is merely a mathematical mapping from points in one view to points in the second. When corresponding points are mapped together, the registration is successful.

The next section of this paper explains related work on image registration. The third section contains a brief explanation of the transformation method used for image registration. In the forth section, the registration procedure is introduced in detail with its steps. In next section, we present some experiment results. Finally, concluding remarks are provided.

II. RELATED WORK

Many discussions have been carried out previously on Image Registration. This section of paper provides an immediate look on the significant research work for image registration. Image registration using wavelet based approach, discrete wavelet transforms algorithm [3] is used to decompose the images. Single level decomposition is used in reference [4]. To estimate the feature correspondence, correlation coefficient (cc) is computed as similarity measures. Other types of similarity measures can be used, too. Reference [5] uses cc as measure for image registration. As summarized in Refs [6], image registration is based on Wavelet Transform, author utilize the LL wavelet coefficients to register two multimodal images using the sum of absolute difference (SAD) at lower resolution levels and mutual information (MI) at higher resolution levels. The originality of this idea is to apply wavelet in the field of medical image registration and the combination of two different similarity measures. In [7] reference paper brain image is segmented and registered using multi resolution registration. By means of Segmentation, a digital image is partition into multiple regions or sets of pixels.

III. IMAGE TRANSFORM METHODS

This section of the paper focus upon used transforms in process of image registration technique. Here two orthogonal images transforms namely WALSH, HAAR are used for transforming the images. Following are the transforms along with some of the required equations for implementation.

A. HAAR Transform

The Haar transform is the simplest self-similar orthonormal image transform. It is easy to understand and simple to compute. It has the capability to represent different positions as well as different scales. This distinguishes the Haar transform from the other transform.

- *The Haar functions:* The Haar functions $h_k(t)$, ($k=0, 1, 2, 3 \ldots N-1$) are defined on the interval $0 \le t \le 1$. The shape of the specific function $h_k(t)$ of a give index *k* depends on two parameters *p* and *q*:

$$k = 2^p + q - 1$$

For any value of $k \ge 0$, *p* and *q* are uniquely determined so that 2^p is the largest power of 2 contained in k $(2^p < k)$ and *q* -1 is the remainder $q - 1 = k - 2^p$. For example, when N=16, the index *k* with the corresponding *p* and *q* are shown in the table 1.

TABLE1.
FOR N=16 HAAR FUNCTION, THE INDEX *K* WITH THE CORRESPONDING *P* AND *Q* VALUES

K	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
p	0	0	1	1	2	2	2	2	3	3	3	3	3	3	3	3
q	0	1	1	2	1	2	3	4	1	2	3	4	5	6	7	8

When *k =0*, the Haar function is defined as a constant

$$h_0(t) = 1/\sqrt{N}$$

When *k > 0*, the Haar function is defined by

$$h_k(t) = \frac{1}{\sqrt{N}} \begin{cases} 2^{p/2} & (q-1)/2^p \le t < (q-0.5)/2^p \\ -2^{p/2} & (q-0.5)/2^p \le t < q/2^p \\ 0 & otherwise \end{cases}$$

The parameters *p* specifies the magnitude and width (or scale) of the shape and *q* specifies the position (or shift) of the shape. From the definition, it can be seen that *p* determines the amplitude and width of the non-zero part of the function, while *q* determines the position of the non-zero part of the function. The N Haar functions can be form N by N matrix for Haar transform.

For example, when N = 4, we have $H_4 = 1/2 \begin{bmatrix} 1 & 1 & 1 & 1 \\ 1 & 1 & -1 & -1 \\ \sqrt{2} & -\sqrt{2} & 0 & 0 \\ 0 & 0 & \sqrt{2} & -\sqrt{2} \end{bmatrix}$

The functions $h_k(t)$ of Haar transform can represent not only the details in the signal of different scales corresponding to different frequencies but also their locations in time. [8]

A. WALSH Transform

The Walsh is orthogonal transforms. The Walsh matrix and Walsh functions are used in computing the Walsh transform. The Walsh matrix was proposed by Joseph Leonard Walsh. A Walsh matrix is a specific square matrix, with dimensions a power of 2, the entries of which are +1 or −1. Each row of a Walsh matrix corresponds to a Walsh function. Walsh transform matrix is defined using a Hadamard matrix of order N. The natural ordered Hadamard matrix is defined by the formula below.

$$H(2^k) = \begin{bmatrix} H(2^{k-1}) & H(2^{k-1}) \\ H(2^{k-1}) & -H(2^{k-1}) \end{bmatrix}$$

For dimension 2^k *for k =1, k*∈ N,

$$H(2^1) = \begin{bmatrix} 1 & 1 \\ 1 & -1 \end{bmatrix}$$

The natural ordering of the rows of the Walsh matrix can be derived from the ordering of the Hadamard matrix.
Example: For 2 x 2 matrix,

$$W_2 = \begin{bmatrix} 1 & 1 \\ 1 & -1 \end{bmatrix}$$

For 4 x 4 matrix,

$$W_4 = \begin{bmatrix} 1 & 1 & 1 & 1 \\ 1 & -1 & 1 & -1 \\ 1 & 1 & -1 & -1 \\ 1 & -1 & -1 & 1 \end{bmatrix}$$

The Walsh transform matrix row is the row of the Hadamard matrix specified by the Walsh code index, which must be an integer in the range [0... N-1]. For the Walsh code index equal to an integer j, the respective Hadamard output code has exactly j zero crossings, for j = 0, 1... N-1.

Full 2-Dimensional Walsh transform applied on an image of size N x N requires only additions and no multiplications. The numbers of additions required are $2N^2(N-1)$. [9] So, Walsh transform reduces the computational time by a considerable amount.

Thus, we can greatly reduce the complexity of similarity computation while still captures the major difference between features.

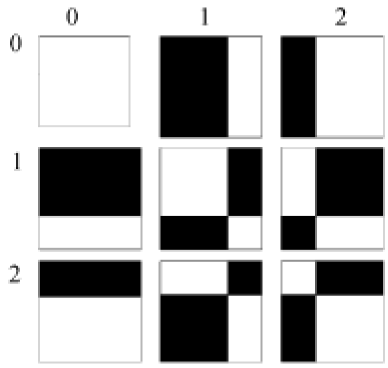

Fig.1 WALSH Transform's basis images for a 3X3 images

Two images I1 and I2, I1 is assumed as reference image and I2 as an image that has to be deformed to match I1. Consider around each pixel, excluding border pixels, 3X3 neighborhood and compute from it, nine Walsh coefficients (3X3 WT of a 3X3 image patch). If 'f' is input image, matrix of coefficients 'g' computed for it using equation (2),

$$g = (W^{-1})^T \cdot fW^{-1} \qquad (2)$$

Matrix g contains coefficients of expansion of the image, in terms of basis images formed by taking vector outer products of the rows of matrix *W* and its inverse W^{-1}. These basis images are shown in Figure1, represent type of local structure for each coefficients of expansion. These coefficients are denoted by $a_{00}, a_{01}, a_{02}, a_{10}, a_{11}, a_{12}, a_{20}, a_{21}, a_{22}$ and these Nine coefficients shown in matrix form as below.

$$\begin{matrix} a_{00} & a_{01} & a_{02} \\ a_{10} & a_{11} & a_{12} \\ a_{20} & a_{21} & a_{22} \end{matrix}$$

These coefficients take value in the range [0, 9]. Moreover normalization given by equation (3) makes method robust to global levels of change of illumination [10].

$$a_{ij} = a_{ij} / a_{00} \qquad (3)$$

The information having dense features and rigid body transformation allows for plenty of redundancy in the system and makes it robust to noise and bad matches of individual pixels which effectively represent lack of local information.

In Figure 1, coefficients along the first row and first column are of equal importance, as they measure the presence of a vertical or horizontal edge, respectively. [5] WALSH kernels is able to measure the similarity between two large sets of image patterns in real-time.

IV. Root Mean Square Error As Similarity Measures

The similarity metrics are used to measure the correspondence between images (or regions). Common examples of image similarity measures include Mean Squares, Normalized Correlation, and Mutual Information etc. The Root Mean Square Error computes the mean squared pixel-wise difference in intensity between image *A* and *B* over a region. It is simple to compute and has a relatively large capture radius, but even linear changes in intensity can result in a poor match.

The formulae for calculated image matrices are:

$$MSE = \frac{1}{N.M} \sum_{i=0}^{N-1} \sum_{j=0}^{M-1} [f(x, y) - f^*(x, y)]$$

$$RMSE = \sqrt{MSE}$$

Where f (x, y) is the input image data and f*(x, y) is block of the reference image.

M and *N* are the matrix dimensions in x and y, respectively. Here the root mean square error is used to compute error between transformation result of each block of reference image and input image. Matching accuracy is done based on the root mean square error (RMSE). Accurate matching must have value of RMSE which is close to 0. For images with moderate differences in content, the registration accuracy is, in general, good with an RMS error of one pixel or less.

V. GENERIC STEPS FOR PROPOSE TECHNIQUE

This technique aims upon using transforms for the purpose of image registration. The registration is done by dividing the reference image into overlapping or no overlapping blocks of predefined size. The matching area extraction is achieved by finding HAAR and WALSH of unregistered input image and each block of reference image. The registration technique work as follow:

1) Input and resize images
2) Image fragmentation
3) Apply Haar and Walsh Transform
4) Compute the root mean square error
5) Threshold selection
6) Show the registered image with Group of correspondence

These steps combine present the image registration for area matching. This process elaborately explains in step below.

1) Input and resize images

In this step, first input the color image to be registered and resize the input image into N x N size which should be power of 2. Convert it into grayscale. Input the reference image and convert it to the grayscale.

2) Image fragmentation

Image fragmentation [13] means dividing any given image into non-overlapping cells or fragments. The size of each fragment is such that it divides the image into N equal parts and also keeping the size of each fragment the same. Fragment the reference image into the overlapping or non overlapping blocks of size N x N pixel.

3) Apply Haar and Walsh Transform

Design HAAR and WALSH matrix of size N x N. The simplest way of achieving localization in both space and spatial frequency is to compute a transform in a small block. [1]

Apply the HAAR and WALSH transform of size N x N on the input image of size N x N and each block of reference image of size N x N individually. [14]

4) Compute the error

For each blocks in reference image and input image, an error is calculated from the error data, mean square error (MSE), root mean square error (RMSE).

5) Threshold selection

In the process of area matching, it is crucial to set a suitable threshold for the position and angle differences. A large threshold will increase the number of false matches, so in order to reduce false matches; the threshold should be set as small as possible. [13] Set the threshold value base on error value (RMSE) accordingly. A good result has error near zero.

6) Show the correspondences in reference image

After setting the threshold value, compare it with each error (RMSE) value which is calculated between block of reference image and input image. The block from reference image having (RMSE) error value less than threshold value is selected. And selected block display in reference image shows the group of correspondence between input image and reference image.

Initially, read the input image and reference image to be registered. Resize input image to predefined size and the reference image is fragments into non overlapping blocks of size N x N. This image registration method applied transform on the input image and each block of reference image. The error is computed between transformation result of each block of reference image and input image. The threshold value is set, based on error values. The threshold value can calculate by taking mean of all error values and set the mean value as threshold value. The blocks of reference image which have error value less than threshold value selected and display it in reference image. This shows the registered input image along with registered reference image, which display the area or object of input image in reference image.

VI. RESULTS AND DISCUSSION

The implementation of the proposed algorithm is done in MATLAB R2010a using a computer with Intel Core2 Duo Processor (2.20GHz) and 2 GB RAM.

The proposed technique works on the idea of applying image registration algorithm explained in the paper on images. To achieve these results, the algorithm is executed with various satellite images. The transform based approach is tested on each of them. Comparing the result of HAAR and WALSH Transform the computational time required for WALSH transform is less than HAAR transform. And the RMSE values are comparatively higher for WALSH Transform. The results obtained are shown in the following figures. The reference image is taken which included the water and forest area and input image is the forest land template. After applying the propose technique, we get the output as follows. Figure2 which shows the fragmented non overlapping blocks of reference image. In Figure3 shows the registered image using HAAR Transform, highlighting the matching forest area from input template (input image) into the reference image. And figure 4 registered the image using WALSH Transform. Figure 5 and figure 6 are the bar graph for HAAR and WALSH Transform respectively between RMSE values and fragmented blocks.

VII. Conclusion

An image registration technique for area matching in high-resolution images uses the orthogonal Haar / Walsh transform which make this technique efficient. And this technique is easy and simple to apply. This technique for image registration which uses the Walsh and Haar transform for area matching, fragment the reference image into number of blocks of N x N size to match with the input image. Haar and Walsh transform design for N x N size is apply on N x N size of blocks of reference image and input image of N x N size. After calculating the error value for each block of reference image with input image, Threshold value is used to select matching area of input image into reference image.

This image registration technique has following characteristics.

1) It is a simple, fast, and easy.
2) Walsh transform reduces the computational time by a considerable amount so, it greatly reduce the complexity of computation.

Experimental results shows that the interest point area is computed using transform based approach Thus, this image registration technique efficiently works for registration of images and use for locating matching area accurately.

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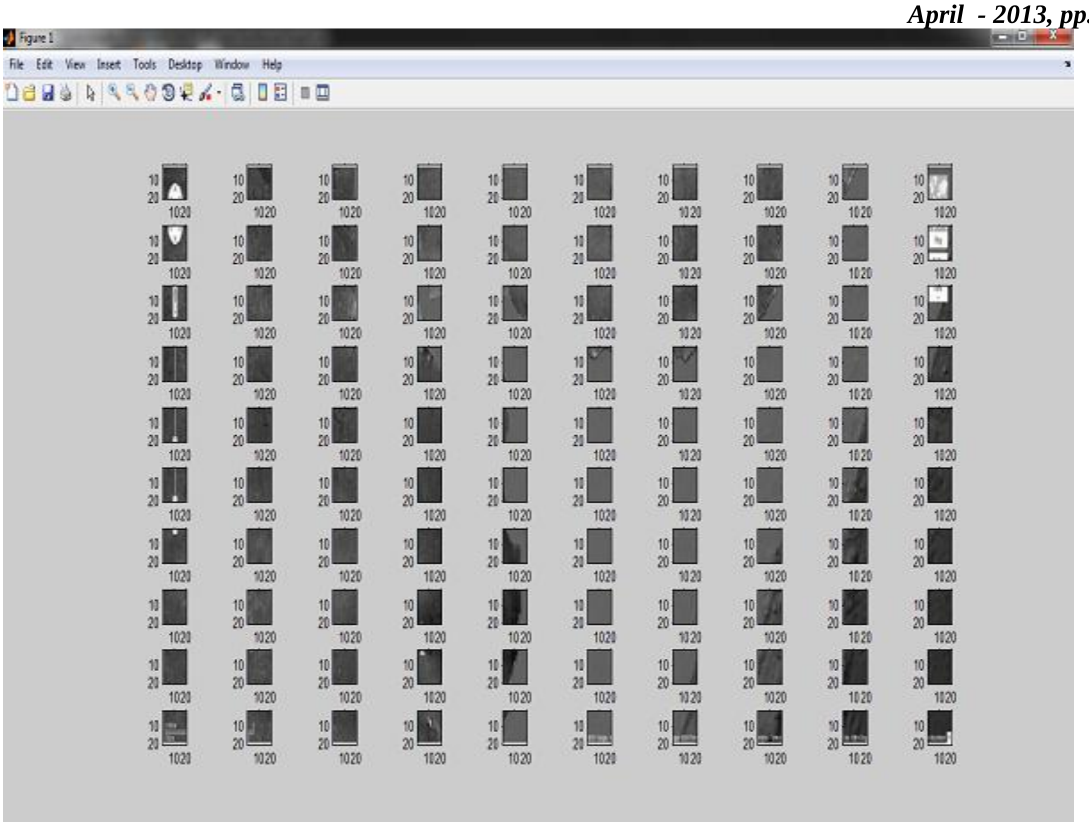

Figure 2. Reference Image Fragmentation into non overlapping blocks in gray scale

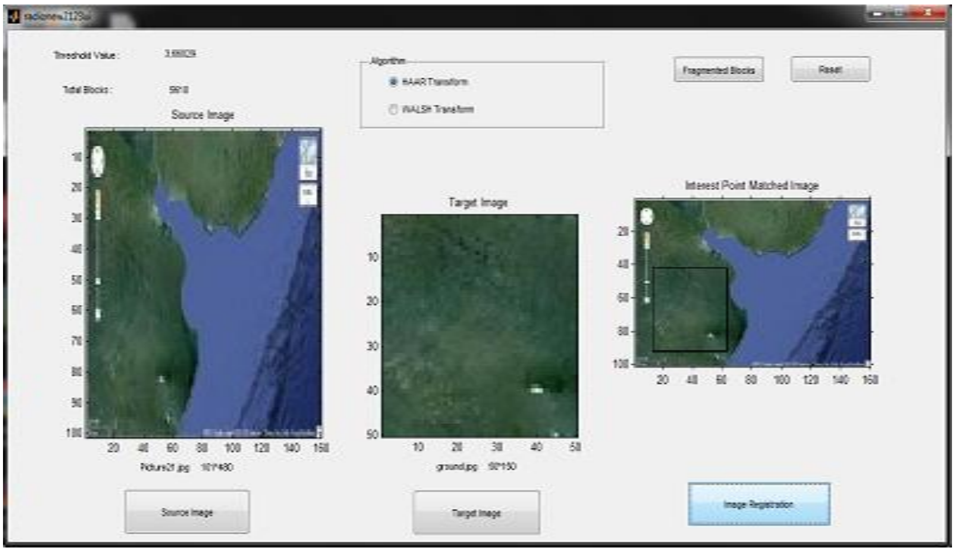

Figure 3. Registered Image using HAAR Transform

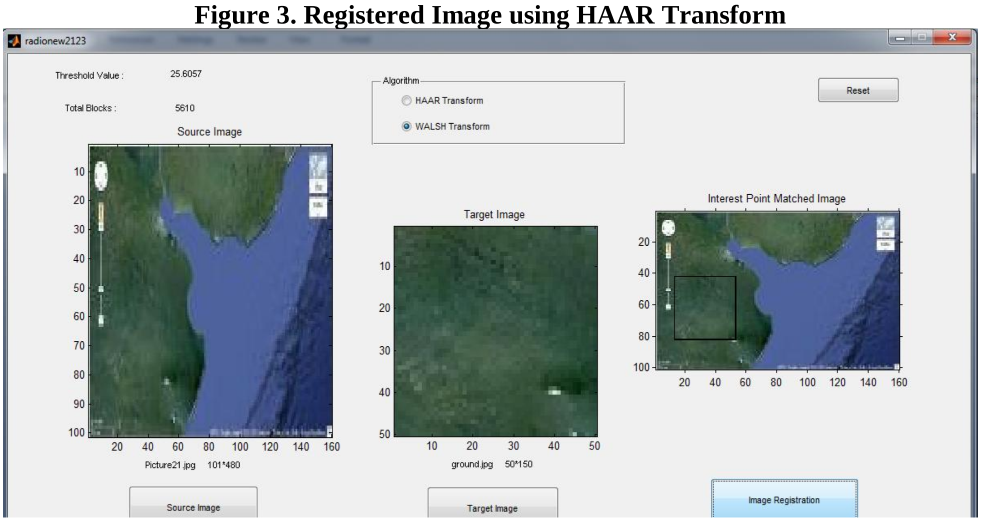

Figure 4. Registered Image using WALSH Transform

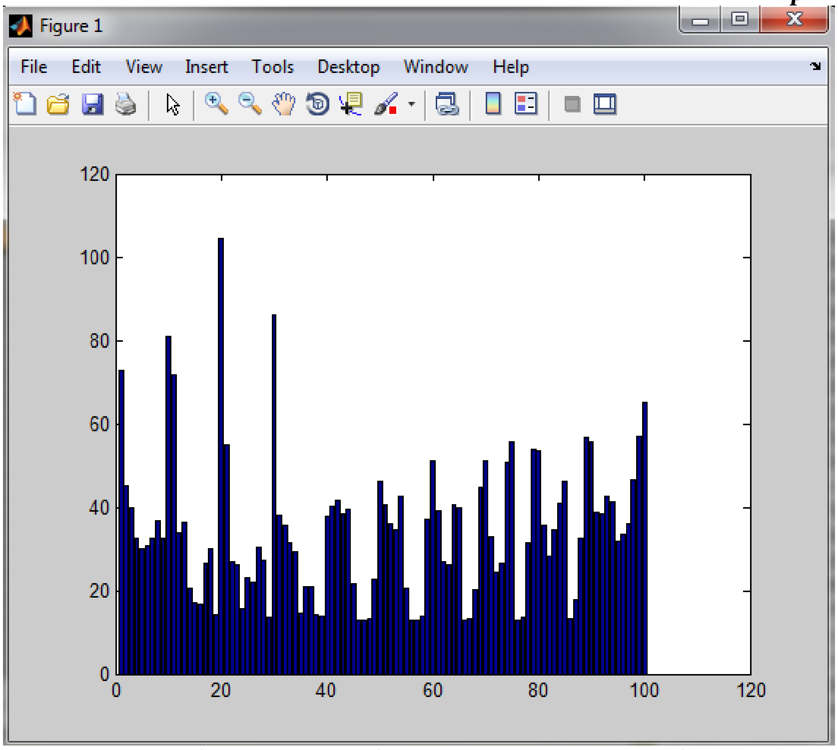

Figure 6. A bar graph for WALSH Transform between RMSE values and fragmented blocks

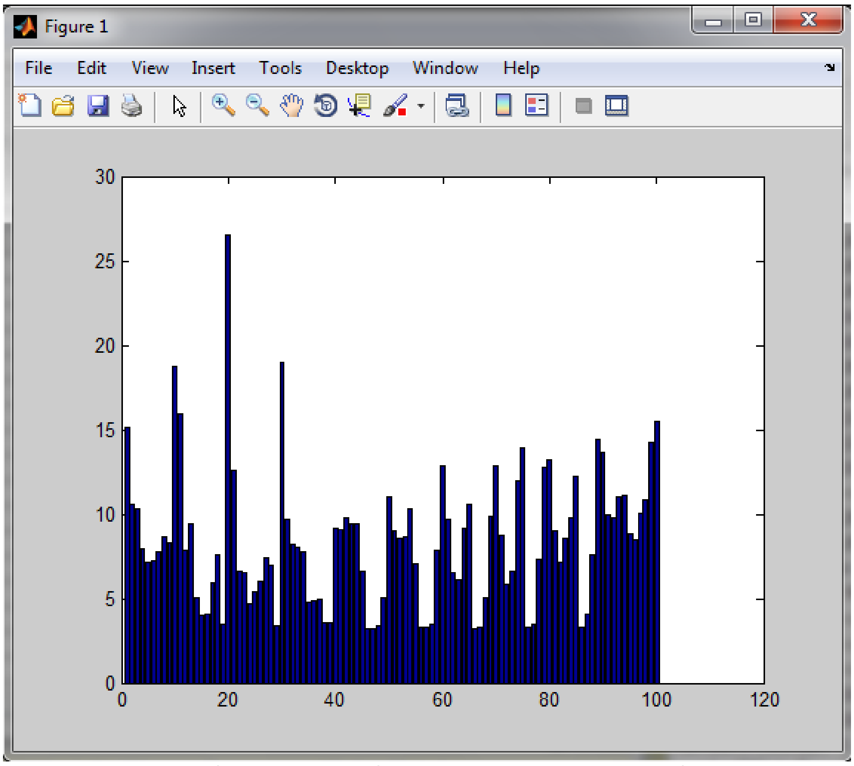

Figure 5. A bar graph for HAAR Transform between RMSE values and fragmented blocks