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Design of Hardware Architecture for Hybrid SIFT

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***Abstract*— Real-time performance is a critical demand to most of the applications, which require the detection and matching of the visual features in real time images. This process establishes the correspondence between two images taken at different time. The proposed hybrid SIFT features are invariant to change in scale, rotation and intensity. This algorithm has been used in navigation for detection of ships and planes, used in traffic controls and detection of objects in many applications.The hardware architecture to detect stable keypoint module and descriptor generator module has been designed. The input image is driven from a digital camera for real time implementation and the pixel values are recorded for the key point detection. The key points are obtained using FAST corner detector and the images are matched based on the key point obtained. The edge response rejection module is used to eliminate edge features of the image which makes the key-points unstable. After the detection of stable key points, the orientation and magnitude are calculated for each pixel to perform image matching. In the proposed hybrid SIFT, FAST key points and SIFT descriptor recognizes the image in an effective and efficient manner. The hybrid SIFT minimize the time due to less key points and the rotation delay is reduced above 60 0 . The proposed hybrid SIFT has been verified using MATLAB R2013B for various images. The hardware architecture has been simulated using ISim p2.8xd and tested for various images.**

***Index Terms*— Scale Invariant Feature Transform (SIFT), Features from Accelerated Segment Test (FAST), Difference of Gaussian (DoG)**

I. INTRODUCTION

Real-time performance is a critical demand to most of these applications, which require the detection and matching of the visual features in real time. The hardware architecture for image feature extracts key point in an image key point in the image is a pixel which has a well-defined position and can be robustly detected. The evaluation of the descriptors is performed in the context of matching and recognition of the same scene or object observed under different viewing condition.It can overcome the matching difficulties caused by the different orientation and scale in close-range images, and it provides every key point a unique descriptor that will make the image matching or registration more reliable. SIFT algorithm consists of four stage filtering approach i) Scale space extrema detection ii)Key point localization iii)Orientation assignment iv)Keypoint descriptor. The scale space extrema stage of filtering attempts to identify those locations and scales that is identifiable from different views of same object.

In the proposed hybrid SIFT, key points are obtained from FAST corner detector by comparing 16 neighbourhood inter pixels around the selected pixel value. By using this proposed algorithm, stable points are attained easily without any complexity. In this proposed algorithm, comparison of key points is within 16 pixels values, but in SIFT Difference of Gaussian(DoG) assessment is made between 26 pixels and then elimination of key points are made by hessian matrix.

The architecture has been described for the hybrid SIFT. The Hybrid SIFT feature detection in real time has been done for images of various sizes. In real time applications the input section of Hybrid SIFT detector is driven by camera. The detailed description of each block is discussed in later chapters. The architecture of both stable keypoint detection module and descriptor generator module is coded in Verilog. Hybrid SIFT algorithm mainly contains two parts, i.e. feature point detection and descriptor generation. The design is focused on the feature detection with invariance to image rotation, scaling, translation and illumination changes

II. HYBRID SIFT ALGORITHM

In the SIFT more key points are extracted, mismatch of images occur due this more number of key points. To remove this mismatch and reduce the time consumption, proposed hybrid SIFT algorithm is applied here [3]. In the hybrid SIFT, key points are obtained from FAST corner detector by comparing 16 neighborhood inter pixels around the selected pixel value [10].

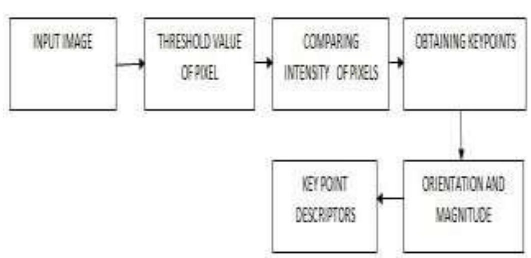

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Fig. 1.1 Block diagram of hybrid SIFT

The magnitude-orientation histogram is used to describe a feature point, which is computed from the gradient magnitude and orientation of the neighbor pixels around the candidate feature point. For each key point 128 feature vectors are obtained. They are called sift keys.

The block diagram of hybrid SIFT is shown in the Fig.1.1.Thus the key points are obtained and the images are matched based on the key point obtained. The proposed hybrid SIFT algorithm is described below:

Step 1: In the proposed hybrid SIFT, key point are obtained using FAST corner detector. The FAST corner algorithm is explained below.

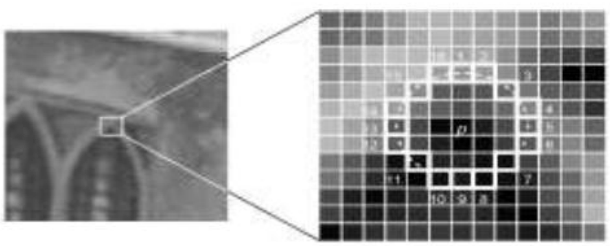

Fig.1.2 FAST corner detection

1. Select a pixel ―p‟ in the image. Assume the intensity of this pixel to be Ip and this pixel is identified as an interest point or not based on the given criteria shown in the Fig 1.2

2. Set a threshold intensity value T, (say 20% of the pixel under test).

3. Consider a circle of 16 pixels surrounding the pixel p as shown in Fig.1.2.This is a Bresenham circle 4 of radius 3.

4. If ―N‖ contiguous pixels out of the 16 need to be either above or below Ip by the threshold value, then the pixel needsto be detected as an interest point (N =12).

5.Each value (one of the 16 pixels, say x) in the vector, can take three states. Darker than p, lighter than p or similar to p. Mathematically,

$$S_{p\to x} = \begin{cases} d, & I_{p\to x} \le I_p - t \quad \text{(darker)} \\ s, & I_p - t < I_{p\to x} < I_p + t \quad \text{(similar)} \\ b, & I_p + t \le I_{p\to x} \quad \text{(brighter)} \end{cases}$$

Sp x is the state, Ip x is the intensity of the pixel x. and t is a threshold.

7. Depending on the states the entire vector P will be subdivided into three subsets, Pd, Ps, Pb.

8. To make the algorithm fast, first compare the intensity of pixels 1, 5, 9 and 13 of the circle with Ip. At least three of these four pixels should satisfy the threshold criteria so that the interest point will exist.

9. If at least 3/4pixel values I1, I5, I9 I3 are not above or below Ip +T, then P is not an interest point (corner). In this case reject the pixel p as a possible interest point. Else if at least three of the pixels are above or below Ip +T, then check for all 16 pixels and check if 12 contiguous pixels fall in the criterion.

10. Repeat the procedure for all the pixels in the image.

Step 2: After the detection of stable key points, the orientation and magnitude are calculated for each pixel.

a) Orientation Assignment

Remove effects of scale and rotation. For a given pixel (x, y) the gradient magnitude and orientation are computed as
Magnitude = (((L(x + 1,y)- L(x – 1, y))^2 + (L(x, y + 1) - L(x,y - 1))2)^0.5
Direction = 1/(tan(L(x ,y+1)- L(x , y-1)) / (L(x+1,y) - L(x-1,
y))).

Step 3:Local gradient data used to create key point descriptors. Gradient information is rotated with orientation of key point.

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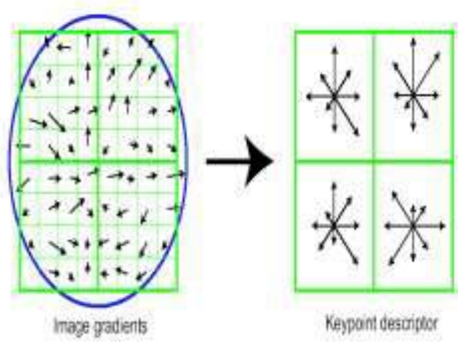

Fig.1.3 SIFT descriptor

SIFT key point descriptor in Fig.1.3 uses set of 16 histograms, aligned 4x4 grid, 8 orientation bins. Feature vector containing 128 elements. They are Sift keys. The main aim of the proposed model is to match two images in a faster way for rotation, scaling and intensity compared with SIFT.

III. HYBRID SIFT ARCHITECTURE

The hardware implementation design is based on four stages of processing. It includes image to text file conversion, keypoint extraction, magnitude & orientation and descriptor generator. The process diagram of the proposed system is shown in Fig.1. 4.

In the Step1 the input image is first converted into text file. The filtering section is separable and provides row and column operation for every pixels, which provides better smoothening of the image. The clock signal is used to select the row and column pixels. Reset is used to decide the read or write file declaration. The FIFO performs like shifting registers from outside, where the data is shifted into the first FIFO buffer, in a data stream manner. In the next step pixel comparison is made with neighboring pixels. In the pixel comparison, centre pixel is compared with the surrounding 16 pixels based on the threshold value. Keypoint detection method includes extreme value detection, from the pixel values maximum value is chosen so that the stable corner key points are attained. Eliminate more points from list of key points by finding the low contrast or low poorly localized on edge. Low contrast points are eliminated and stable key points are attained using FAST corner detector.

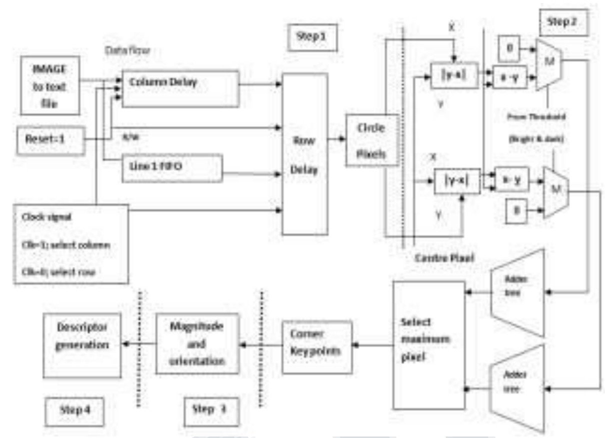

Fig.1.4 Hardware architecture of hybrid SIFT

In the third stage the magnitude-orientation histogram is used to describe a feature point, which is computed from the gradient magnitude and orientation of the neighbour pixels around the candidate feature point. For a given pixel (x, y) the gradient magnitude and orientation are computed. After the magnitude-orientation histogram, the image descriptors obtained are used for feature matching purposes in image processing applications. Hence the descriptor vector is normalized to unit magnitude.

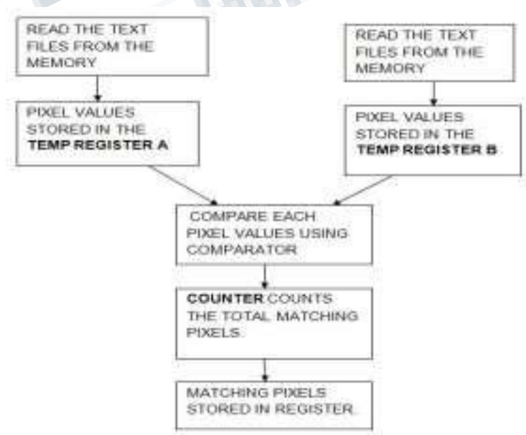

Fig.1.5 Comparison of two images

Matching accuracy is used to verify the system reliability. The key points are matched based on the two descriptors for matching, among all points. The correct matching points are detected on the comparator is shown in the Fig.1.5.

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III. RESULTS AND ANALYSIS

Analysis is made for different real time gray scale and colour images in MATLAB 2013a for different rotation, scaling and intensity invariant.

A. Simulation using Matlab for Images

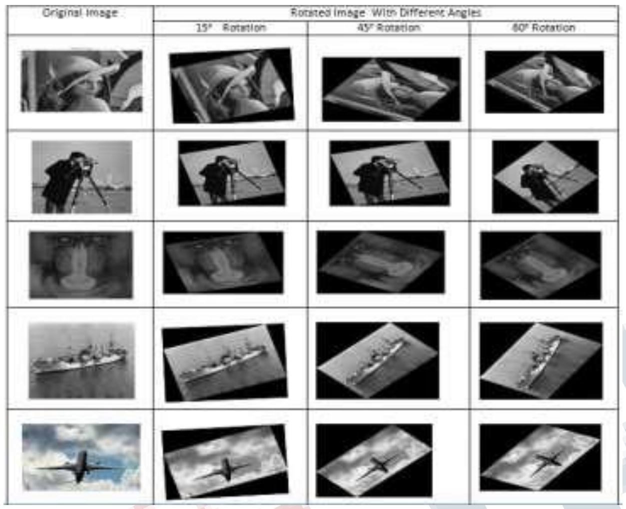

Fig.1.6 Images with different rotations

The algorithms have been tested using different gray scale images that the rotation changes from 150 to 600 is shown in the Fig.1.6. Rotation invariance is the critical feature used in the assessment and comparison of feature detectors. The same image corpus has been rotated and results reveal that the hybrid algorithm computes less time when compared with SIFT and FAST is shown Fig.1. 7. Hybrid SIFT surprisingly, generates less correct matches than the SIFT between 45 and 60 degree.

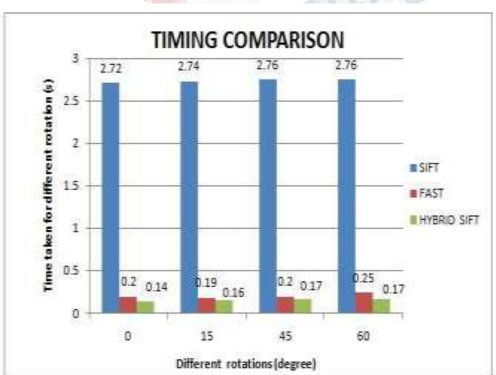

Fig.1.7 Rotation comparison (Lena image)

The algorithms have been tested using different gray scale images that the scale changes lies in the range from 0.6 to 3.SIFT descriptors outperform other local descriptors on both textured and structured scenes, with the difference in performance larger on the textured scene. The input images with different scaling factors are shown in the Fig 1.8.

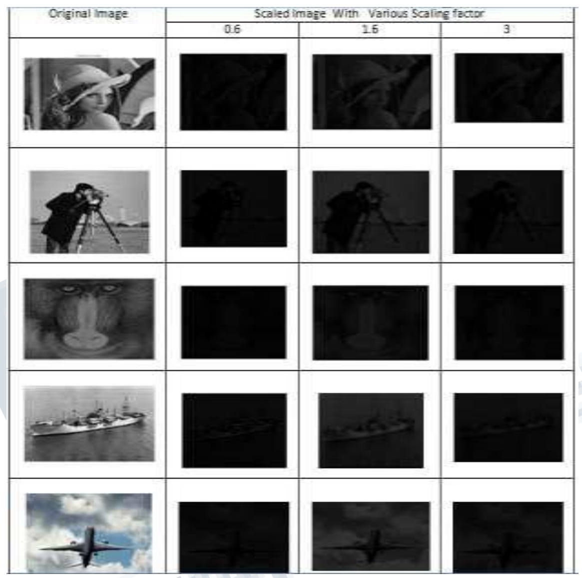

Fig.1.8 Images with different scaling

According to which, total number of correct matches obtained from the hybrid algorithm is far more than the SIFT and FAST corner detector in terms of resistance to the scale changes as seen in the corresponding Fig.1.9.

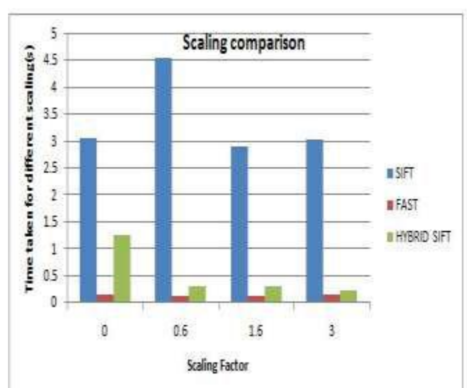

Fig.1.9 Comparison of different scaling

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Fig 1.10 illustrates intensity variations obtained for different images under different intensity values. By increasing the intensity values the matched output is checked for three algorithms. The output for these algorithms is thus discussed for each intensity values.

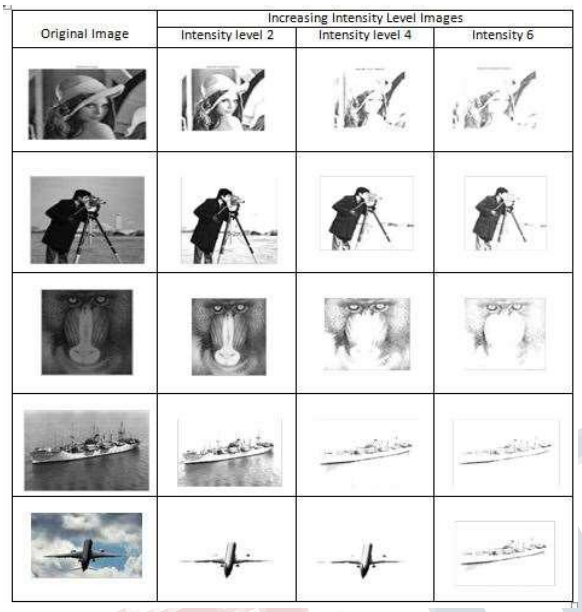

Fig.1.10 Images with different intensity

The image matching intensity occurs in the range between 0 to 6. From these analyses intensity has 100% matching efficiency in SIFT algorithm but in FAST efficiency is thus reduced. Compared with existing methods, hybrid SIFT gives better performance as shown in Fig 1.11

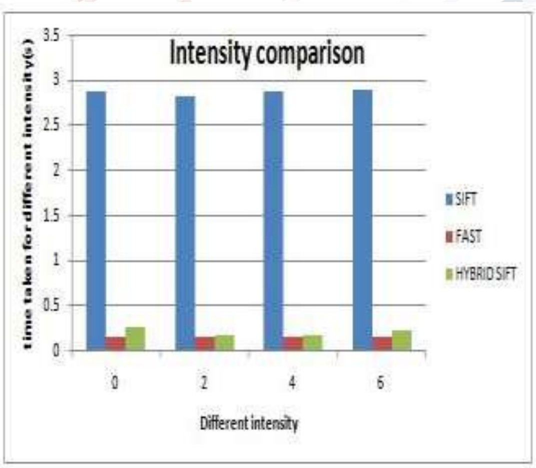

Fig.1. 11 Comparison of different intensity

B. Hardware Simulation

Xilinx ISE 14.2 is used for generate RTL & FPGA schematic. The design is simulated using Xilinx ISE Design suite 14.2 with Verilog coding language. For the feature detection an image should be given as input. A test input image is converted into corresponding pixel using MATLAB for verification. The simulation output for the line buffer circuit with the image given. It outputs each pixel values one after the other with one clock pulse delay is shown in the Fig.1.12. The input pixels are stored in the temporary register

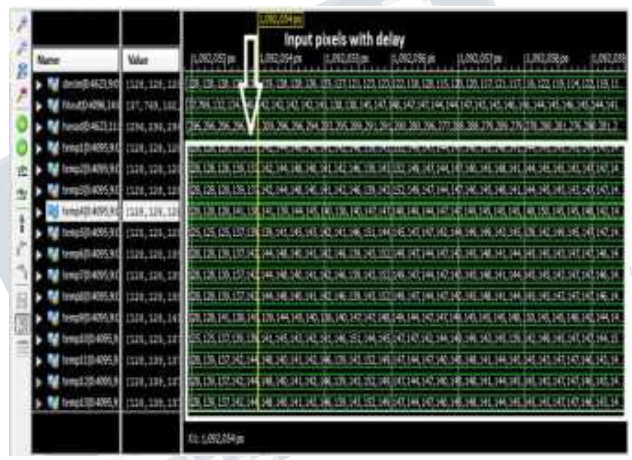

Fig.1.12 Simulation results of input pixels

Fig.1.13 Indicates the key-point detected from the feature detection module which shows that usually the extreme pixel value is considered as the key points.

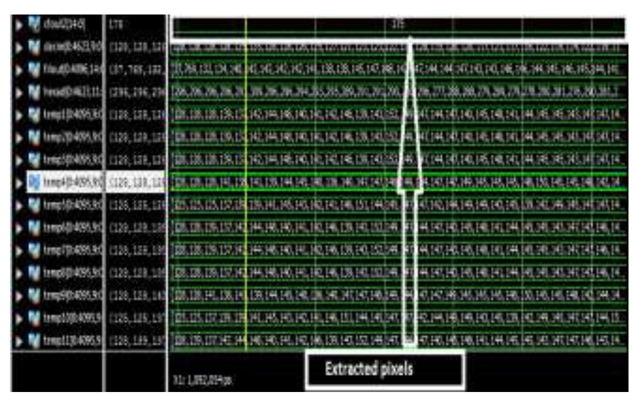

Fig.1.13 Simulation result of key point extraction

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The simulation result shows the total number of key points extracted from the image is shown in the Fig.1.14 and simulation of RTL is shown in the Fig.1.15 .

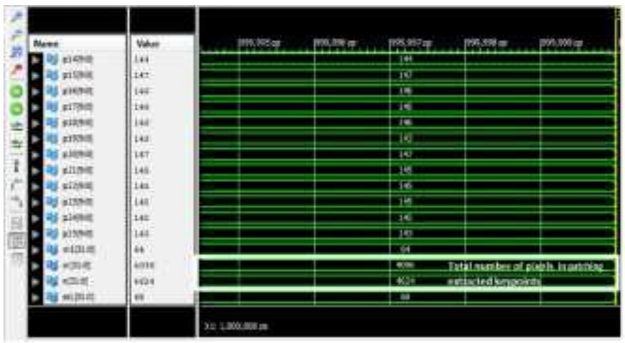

Fig.1.14 Simulation result for total Number of key point

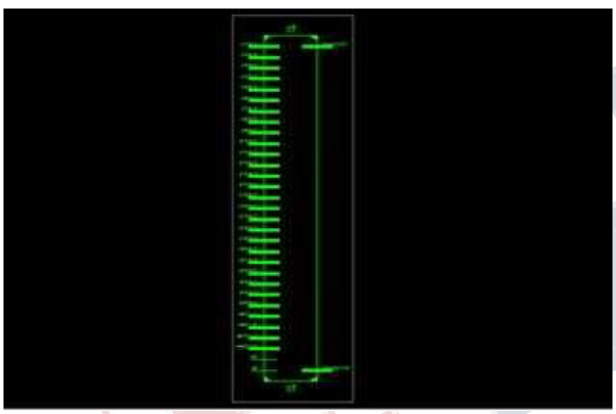

Fig.1.15 Simulation result for RTL

The two input image is converted into corresponding pixel using MATLAB for verification. The two input text files are stored in the temporary variables and compare each pixel in the text files are thus simulated shown in the Fig.1.16

Fig.1.16 Simulation result of two text file

The two text files are thus compared and the matching pixel count are counted is shown in the Fig.1.17.

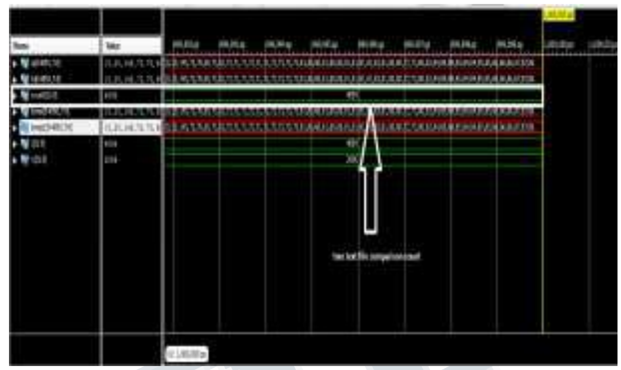

Fig.1.17 Two text files comparison (matching)

A computationally efficient feature detector based on hybrid SIFT algorithm is implemented in this design. In this work hardware architecture for image feature detection in real time was designed. By this design a stable and reliable scale space extrema detection is achieved based on hybrid SIFT algorithm. This design is focused on the feature detection with invariance to image rotation, scaling, translation and illumination changes.

IV. CONCLUSION

In the proposed algorithm, the reduction of a large set of key points which we collected using different keypoint extraction methods and their combinations. The algorithm primarily integrates FAST corner detector into the SIFT's descriptors in order to detect the key points in fast manner. The main intend of this proposed method is to identify the images in a fast manner with less number of key points. Hybrid SIFT algorithm is implemented in the hardware architecture for image feature detection in real time was designed. By this design a stable and reliable key point is achieved based on hybrid SIFT algorithm. The speed of proposed Hybrid SIFT for detecting the keypoint is thus increased 20% more than the SIFT algorithm.Thus the hybrid SIFT is suitable for real time applications. The results are thus concluded based on hybrid SIFT performance. Results reveal that this hybrid algorithm decreases the computation time of key point and generates more correct matches than two leading feature extractor algorithms under different experimental conditions, including scale, rotation and intensity changes problem. The proposed method are simulated using

MATLAB2013a and hardware architecture of hybrid sift is implemented in Xilinx. Real-time hybrid SIFT algorithm for feature point extraction is possible by using hardware architecture and FIFO buffer. In future hardware architecture of hybrid SIFT for video recognition will be designed and executed in FPGA.

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