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FPGA Implementation of Image Block Generation ,Color Space Conversion and background identification for the Gaussian Mixture Model

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***Abstract* — Due to high rise in demand for video processing on hardware FPGA implementation of various image processing algorithm has become a necessity. Lot of research work is being done in the field of image processing and video processing on FPGA. Identification of an object and tracking its movement is very rescue in the field of computer based vision and image processing. In this paper we specifically concentrate on working Background identification, moving object detection and tracking. Keeping in mind the previous work dons in this area we have selected Gaussian mixture model for the implementation. The paper speaks about three block of implementation mainly the image block generation and the RGB to YCbCr conversion and background identification and updation. It has been proved from the design that it is efficient for high definition (HD) video sequences with frame size 1920 × 1080. Both the bocks are targeted on commercial field-programmable gate-array (FPGA) devices. When implemented on Atrix7 100t it uses 3% of FPGA logic resources. The second block takes like 2% of the FPGA resource. The third block takes like 3% of the FPGA resource. The total time required to process single frame is less than 2ns .**

Keywords — **Image Processing, Field Programmable Gate Array(FPGA), Gaussian Misture Model, Color Space Conversion, Memory element.**

I. INTRODUCTION

Intelligent surveillance system is one of the most in demand system these days, due to rise in demand for better security. These surveillance systems mostly works on moving object detection and tracking in a given video stream. It has become a challenge to develop a real-time implementation of moving object detection algorithm to reduce the time and improve the efficiency of the system. Generally moving object detection and tracking done on video that in uses a visible light image sensor and sometime based on thermal infrared based sensors. Once the video is available image processing algorithm is applied on the target video to extract various features in the given stream of video. Features like motion parameters include position of the target object, velocity of the moving object. Basically moving object detection and tracking are two process which are very closely related to each other. Hence, they share most of the common features obtained from the image processing algorithm

In other words we can also relate motion analysis with other image processing methods namely pattern recognition, computer vision, artificial intelligence and similar implementation. It is very challenging to obtain the features of object and do segmentation in the provided video for fast moving objects in dynamic picture. In our paper we have proposed a system for generation of 3X3 overlapping block generation from the given input image for the processing of the data. The design comprises of memory element which stores the data and produces as per the requirement. The design made for 3x3 to reduce the design complexity and increase the computional speed due to less data. It also proposes a simple design for color space conversion of the input image which converts the given RGB image to YCbCr color space conversion.

The increase in demand for segmentation in high speed video for moving object with dynamic scenes has thrown a lot of challenges in front of designers. Some technologies such as stop treatment based method for motion analysis has made some work easy also occlusion based on non rigid motion has played a very vital role as discussed [4,5]. Motion detection and segmentation has found out various other application other than basic traditional system. Application such as virtual reality, Automatic navigation, target acquisition by robot, etc. has been discussed that throw light on importance of moving object detection and segmentation [6]. Due to recent development in technology for image processing specially in field of pattern recognition, artificial intelligence, etc. the use of moving object detection and its application has been widely found in day to day use and also in high end military applications.

The greatest challenge in motion detection is understanding the data classification problem. This is because the data is time varying and matching the test data with the reference data which is continuously varying or dynamic data input. This is the biggest problem as discussed in [7, 8]. Hence it is very much necessary to obtain the data or the reference data from set of data by using learning algorithms. The algorithms are developed in such a way that if there is any minor displacement or distraction the analysis will do the right selection of reference. Once the data is made as a reference the job is almost half done. The next challenge in the process is about classification of the data from the main input. This is one of our main target to be achieved. The very good explanation about the classification of the object of interest has been discussed in [9] where we get the clear picture of classification. After the classification continuous and correct tracking is an important activity to be carried out in the process. Moving object detection and tracking has been explained very well in [10, 12]. As per the paper there are mainly two main difficulties one is about the acquiring of the data and storing in and giving it as an input to the processing element. The challenge is that the quantity of the data is too high and all of it has to be processed in the given stipulated time only any delay may cause the system to malfunction. Second biggest challenge is about the motion detection and tracing for the data in complex background. Various experiments and analysis has been carried out on performance evaluation of the used algorithm such as Mean Shift based moving objet detection, traditional update algorithm, etc. Considering all the drawbacks and advantages of the previous algorithms an overall target model of an updated algorithm has been proposed in the paper which has got capabilities of improving the performance of the system.

Gaussian Mixture Model(GMM) was proposed by two scientist Mr. Stauffer and Mr. Grimson. The biggest advantage of GMM is that it has an efficient method to work with multimodal background based on statistical model to be composed of Gaussian distribution. The GMM is very useful and works as an important component in many design so it has been modified and updated in Open CV libraries for the easy of use and made quite available. Below shows the basic block diagram for the GMM model.

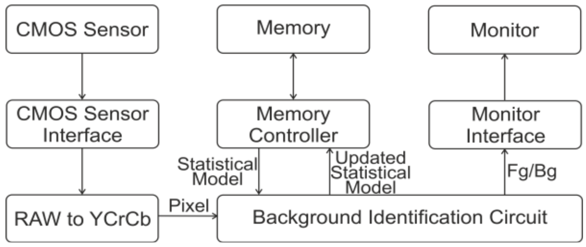

Figure 1. Block diagram for GMM

As shown in the figure1 we can make out that there are three main component in GMM , 1) Image acquisition block comprising of CMOS sensor and the interface along with color space conversion. 2) Background identification module this is the heart of the project. The algorithm for detection and tracking is implemented in this block and is used for the final decision making in term of object detection and tracking. 3) Third main component in the block diagram is external interfaces with display unit such as monitor and different types of memory elements.

This paper is organized as follows. Section 2 gives a generation of 3x3 block and motion detection. Section 3 presents the block conversion of RGB to YCbCr. Section 4 presents the background identification module. section 5 presentsthe FPGA implementation simulation and synthesis results and the Comparison with other work. Conclusion and future work is given in Section 6.

II. Block Generation Unit

The design is implemented on MATLAB for checking the functionality of the GMM algorithm on the given input data. The design is coded in matlab for the standard video of traffic movement and evaluation was done by check the detection and tracking for the input provided to the design. Below shows some of the results obtained by running the design in MATLAB.

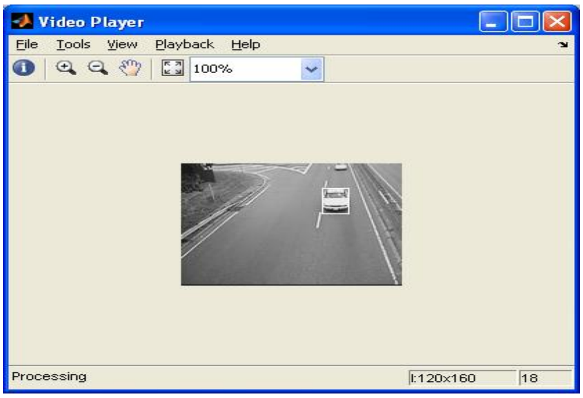

Figure 2: output for showing single object tracking

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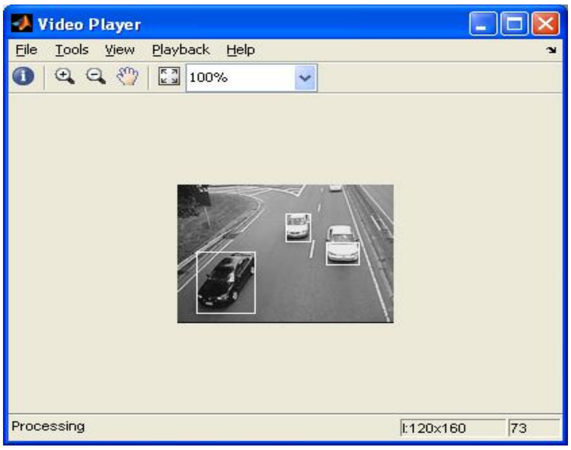

Figure 3. Output for showing multiple objection detection and tracking

Above figure2 demonstrate the results obtained by running the MATLAB code for the input where only single moving object is detected and tracked for the given video using GMM algorithm. The same design was provided with video with multiple moving object for detection and tracking and we can see from the figure3 that it has successfully obtained the required results for multiple object detection and tracking.

The main concentration has been given in development of memory element for generation of 3X3 block for the further processing of the image. In generation of the same the Ram bock is incorporated of size 776 location with each location having 8bit resolution. Data in serial format of 8 bit each enters the register as a temporary data and is passed on the memory element the process is carried out for 2 clocks to obtain the first 3X3 elements in overlapping mode. Below show the basic block diagram for the memory element for the generation of necessary block.

Input pixel of 8bit each

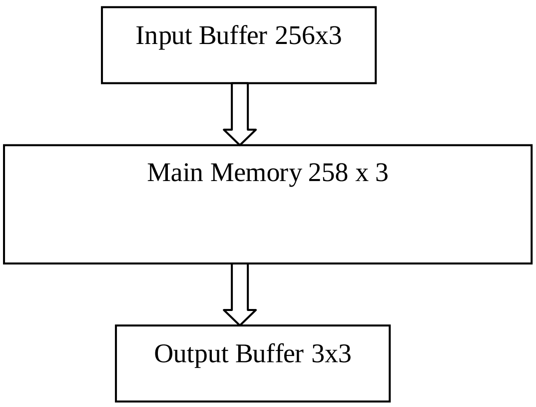

Figure 4: block diagram for Block generation unit

Above figure4 shows the basic block diagram for the implementation of the design. The design is implemented in such a manner that it is quite efficient in generation of 3X3 block with minimum usage of the memory.

III. COLOR SPACE CONVERSION

The mathematical representation of color set is called as color space. These representations are not directly related to the hue, saturation and brightness. There are basically three types of color space model namely RGB this format is used for computer system. YCbCr, YUV or YIQ plays a very important role in video processing system and CMYK this color space finds its place in color printing.

Table 1. 100% RGB color bars.

	Nominal Range	White	Yellow	Cyan	Green	Magenta	Red	Blue	Black
R	0 to 255	255	255	0	0	255	255	0	0
G	0 to 255	255	255	255	255	0	0	0	0
B	0 to 255	255	0	255	0	255	0	255	0

RGB is the most common standard used for the display of image as it is most prevalent choice in display graphics. Any kind of color can be created using the combination of RGB. However it cannot be used for processing of video as the frame buffer needs to have pixel depth and display resolution for each RGB component. This can be cleared with an example, assume the intensity of the given input image needs to be modified. In this process we need to develop the unit that needs to work on the entire three components independently and regenerate each RGB value and rewrite the new values on the frame buffer as shown in figure5. This process generally takes more time compared to other color space such as YCbCr where we just need to work on only the intensity instead the color component which makes the work faster and easy with less computational complexities involved.

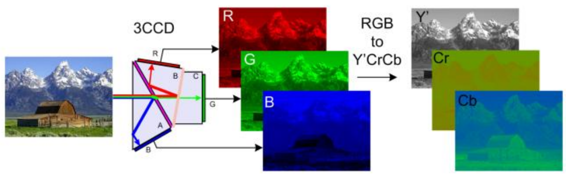

Figure 5: Representation of RGB to YCbCr format

YCbCr is the color space standard that is used for real time video and image. It is widely used in all the video standard such as PAL, NTSC, SECAM and composite color video standard. Even the Black and white only the Y component is used. Further Cb and Cr component were also introduced. As mentioned earlier RGB is widely used for all the display unit data available to the user is always in this format and it is very much necessary to convert the RGB format to YCbCr format. Below shows equation that are used for the transformation of image form one to the other format.

$$\mathbf{Y= 0.299R` + 0.587G` +0.114B`}$$

$$\mathbf{U= -0.147R` -0.289G` +0.436B`}$$
$$\mathbf{= 0.492 (B` -Y)}$$

$$\mathbf{V= 0.615R` - 0.515G` -0.100B`}$$
$$\mathbf{= 0.877 (R` - Y)}$$

Equations shown for Conversion of RGB to YCbCr and they are very much necessary to be converted into digital format in order to implement on FPGA. Hence, the architecture is implemented based on LUT structure in order to execute the above equation. The design make use of standard predefined LUT sturectue in order to reduce the design complexities and also to reduce the area on chip.

IV. BACKGROUND IDENTIFICATION CIRCUIT

Background identification module plays the main role in the research work. This circuit avoids the false triggering and it updates the memory with the help of memory controller. This model can be explained by analyzing the sub-modules of Background identification circuit as shown in the fig 6.

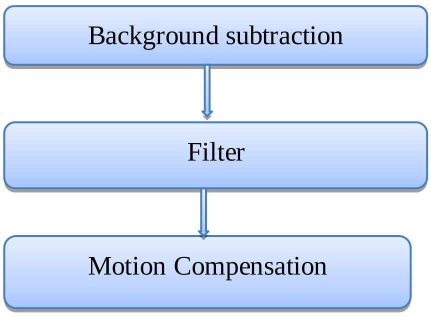

Figure 6: sub modules of background identification circuit

Background subtraction: Background Image pixel and Current frame Image pixel are given as the inputs for this module . Here we get the object which is in motion compared with the background image.the block diagram of first module is shown in the fig 7.

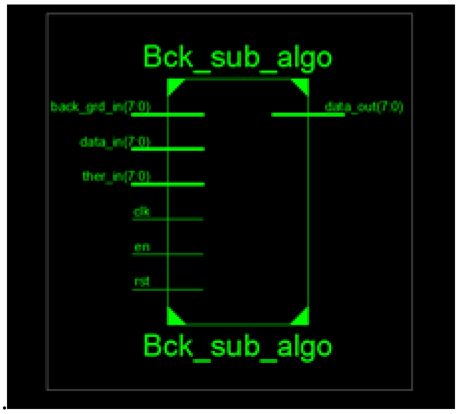

Figure 7: RTL Schematic block diagram of background subtraction

Filter: the object which is in motion is filtered to remove the unwanted noise (distorted pixels). The block diagram of closing filter is shown in the fig 8.

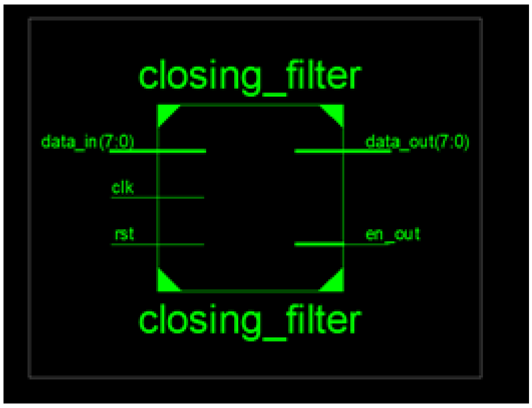

Figure 8: RTL Schematic block diagram of closing filter

Motion Compensation: We get the actual motion object's Image pixel which is undistorted and smoothened image.its internal block diagram is shown in the fig 9.

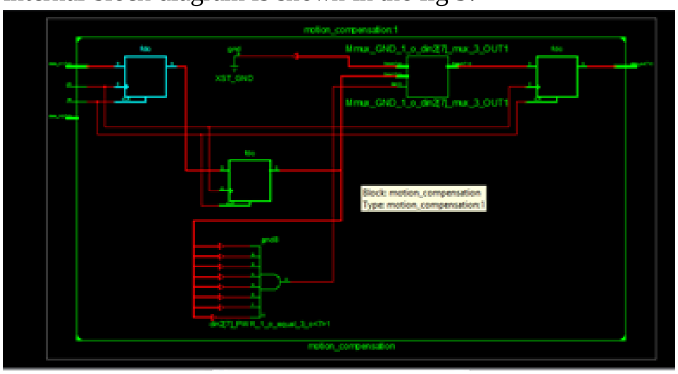

Figure 9: RTL Schematic internal block diagram of motion compensation module

V. RESULTS AND COMPARSIONs

The synthesis results show that there is only 4% device utilization in the above mentioned architecture. RTL schematic for the design is shown in the below figure 10 .

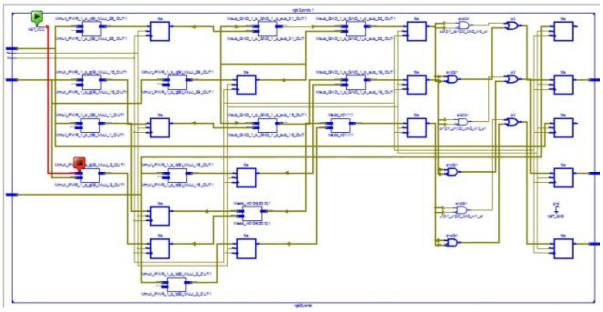

Figure 10: RTL Schematic for RGB to YCbCr

Table 2 gives the total device utilization for 3x3 generated block shows the consumption of just 6% of the total device.

Table 2 . Design summary for Block Memory Generation

Device utilization summary (estimated values)			
Logic utilization	Used	Available	utilization
No of slice registers	8424	126800	6%
No of slice LUTs	5267	63400	8%
No of fully used LUT-FFpairs	221	13470	1%
No of bounded IOBs	22	210	10%
No of BUFG/BUFGCTRLs	3	32	9%

RGB to YCbCr conversion simulation results are observed and verified as shown in below figure 11.

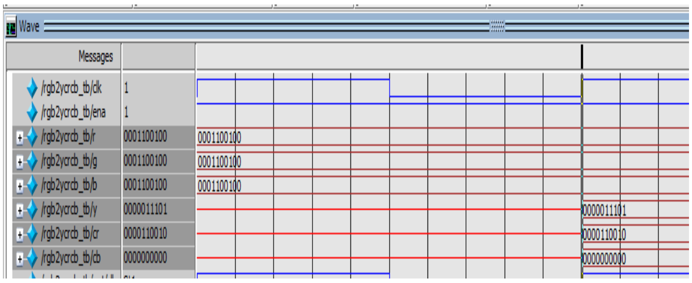

Figure 11: Simulation results for Conversion

Background substraction simulation results are observed and verified with the basic input data's as shown in figure 12.

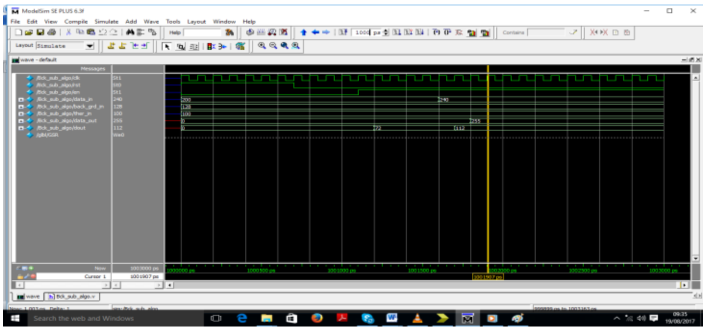

Figure 12: simulation results of background subtraction

Closing filter simulation results are observed and verified with the basic input data's as shown in figure 13.

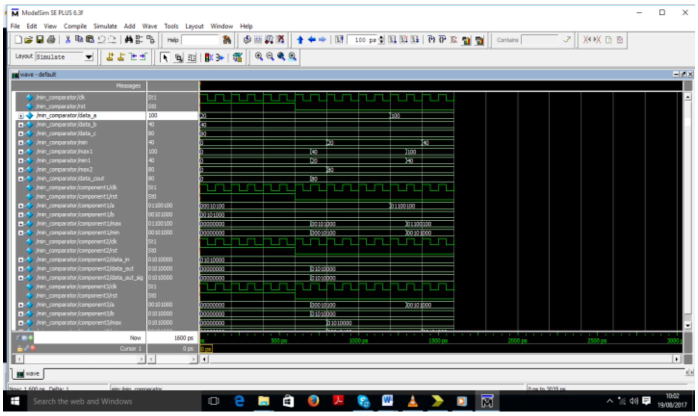

Figure 13: simulation results of closing filter

Motion compensation simulation results are observed and verified with the basic input data's as shown in figure 14.

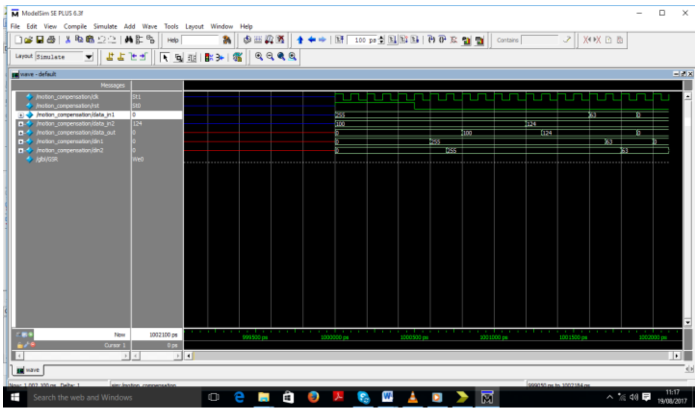

Figure 14: simulation results of motion compensation

VI. CONCULSION AND FUTURE WORK

. In this paper the MATLAB based GMM is implemented for single as well as multiple object detection and tracking has been tested on a standard video. This paper also proposed the FPGA based memory block generation and color space conversion model used as a main module for the Gaussian mixture model. From the results we can conclude that the design developed has competent results as compared to the previous work at the same time we have observed that the architecture is utilizing less area on chip and also has a high speed of operation. The simulation results obtained from modelsim shows the design is functioning as per the requirement and is eligible for the hardware implementation for the correct data output.

REFERENCES

[1] I. Haritaoglu, D. Harwood, and L. S. Davis, "A fast background scene modeling and maintenance for outdoor surveillance," in *Proc. 15th Int. Conf. Pattern Recognit.*, vol. 4. Jan. 2000, pp. 179–183.

[2] P. KaewTrakulPong and R. Bowden, "A real time adaptive visual surveillance system for tracking low-resolution colour targets in dynamically changing scenes," *Image Vis. Comput.*, vol. 21, no. 9, pp. 913–929, Sep. 2003.

[3] B. Gloyer, H. K. Aghajan, K. Y. Siu, and T. Kailath, "Video-based freeway monitoring system using recursive vehicle tracking," *Proc. SPIE*, vol. 2421, pp. 173–180, Mar. 1995.

[4] H. Jieménez and J. Salas, "Temporal templates for detecting the trajectories of moving vehicles," in *Advanced Concepts for Intelligent Vision Systems* (Lecture Notes in Computer Science), vol. 5807. New York, USA: Springer-Verlag, Oct. 2009, pp. 485–493.

[5] Z. Chaohui, D. Xiaohui, X. Shuoyu, S. Zheng, and L. Min, "An improved moving object detection algorithm based on frame difference and edge detection," in *Proc. 4th Int. Conf. Image Graph.*, Aug. 2007, pp. 519–523.

[6] R. Mingwu and S. Han "A practical method for moving target detection under complex background," *Comput. Eng.*, vol. 31, no 20, pp. 33–34, Oct. 2005.

[7] X. Benxian, L. Cheng, C. Hao, Y. Yanfeng, and C. Rongbao, "Moving object detection and recognition based on the frame difference algorithm and moment invariant features," in *Proc. 27th Control Conf.*, Jul. 2008, pp. 578–581.

[8] S. Y. Chien, S. Y. Ma, and L. G. Chen, "Efficient moving object segmentation algorithm using background registration technique," *IEEE Trans. Circuits Syst. Video Technol.*, vol. 12, no. 7, pp. 577–586, Jul. 2002.

[9] C. Ridder, O. Munkelt, and H. Kirchner, "Adaptive background estimation and foreground detection using Kalman filtering," in *Proc. Int. Conf. Recent Adv. Mech.*, 1995, pp. 193–199.

[10] K. P. Karmann and A. Brandt, "Moving object recognition using an adaptive background memory," in *Time-Varying Image Processing and Moving Object Recognition*, V. Capellini, Ed. Amsterdam, The Netherlands: Elsevier, 1990, pp. 289–307.

[11] J. Toyama, J. Krumm, B. Brumitt, and B. Meyers, "Wallflower: Principles and practice of background maintenance," in *Proc. Int. Conf. Comput. Vis.*, vol. 1. Sep. 1999, pp. 255–261.

[12] J. C. S. Jacques, C. R. Jung, and S. R. Musse, "Background subtraction and shadow detection in grayscale video sequences," in *Proc. 18th Symp. Comput. Graph. Image Process.*, Oct. 2005, pp. 189–196.

[13] C.-C. Chiu, M.-Y. Ku, and L.-W. Liang, "Robust object segmentation system using a probability-based background extraction algorithm," *IEEE Trans. Circuits Syst. Video Technol.*, vol. 20, no. 4, pp. 518–528, Apr. 2010.

[14] T. Horprasert, D. Harwood, and L. S. Davis, "A statistical approach for real-time robust background subtraction and shadow detection," in *Proc. IEEE Frame-Rate Appl. Workshop*, Sep. 1999, pp. 1–19.

[15] R. Rodriguez-Gomez, E. J. Fernandez-Sanchez, J. Diaz, and E. Ros, "FPGA implementation for real-time background subtraction based on horprasert model," *Sensors*, vol. 12, no. 1, pp. 585–611, Jan. 2012.

[16] C. Wren, A. Azarbayejani, T. Darrell, and A. Pentland, "Pfinder: Realtime tracking of the human body," *IEEE Trans. Pattern Anal. Mach. Intell.*, vol. 19, no. 7, pp. 780–785, Jul. 1997.

[17] C. Stauffer and W. E. L. Grimson, "Adaptive background mixture models for realtime tracking," in *Proc. IEEE Comput. Soc. Conf. Comput. Vis. Pattern Recognit.*, vol. 2 Fort Collins, CO, USA, Jun. 1999, pp. 1–7.

[18] T. Kryjak, M. Komorkiewicz, and M. Gorgon, "Real-time moving object detection for video surveillance system in FPGA," in *Proc. Conf. Design Archit. Signal Image Process.*, Nov. 2011, pp. 1–8.

[19] S. Y. Elhabian, K. M. El-Sayed, and H. A. Sumaya, "Moving object detection in spatial domain using background removal techniquesstate-of-art," in *Proc. Recent Patents Comput. Sci.*, vol. 1. Jan. 2008,pp. 32–34.

[20] *OpenCV Library on Source Forge*. (2009) [Online]. Available: http://sourceforge.net/projects/opencvlibrary/

[21] P. Carr, "GPU accelerated multimodal backgorund subtraction," in *Proc. Digital Image Comput., Tech. Appl.*, Dec. 2008, pp. 279–286.

[22] V. Pham, P. Vo, V. Thanh Hung, and L. H. Bac, “GPU implementation of extended gaussian mixture model for background subtraction,” in *Proc. IEEE Int. Conf. Comput. Commun. Technol. Res. Innov. Vis. Future*, Nov. 2010, pp. 1–4.

[23] H. Jang, H. Ardö, and V. Öwall, “Hardware accelerator design for video segmentation with multi-modal background modelling,” in *Proc. IEEE Int. Symp. Circuits Syst.*, vol. 2. May 2005, pp. 1142–1145.

[24] F. Kristensen, H. Hedberg, H. Jiang, P. Nilsson, and V. Öwall, “An embedded real-time surveillance system: Implementation and evaluation,” *J. Signal Process. Syst.*, vol. 52, no. 1, pp. 75–94, Jul. 2008.

[25] RGB to YCbCr Color Conversion using VHDL approach E. Prathibha1, Dr.A.Manjunath2, Likitha.R3 *International Journal of Engineering Research and Development ISSN: 2278-067X, Volume 1, Issue 3 (June 2012), PP.15-22* .