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Survey on Serial and Parallel Computing approaches for Real-Time Object Detection, Recognition and Tracking Systems

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Abstract

Object Detection, Recognition and Tracking operations are the important operations involved in machine vision and computer vision applications such as video surveillance, intelligent vehicle systems, person identification system, industrial product quality and quantity checking and many more. In the real time systems, it requires high speed computing approaches and devices to perform these operations. A parallel computing approach is the recent approach after the development of multi-core processor. Parallel computing method gives high performance result then the traditional way of serial computing. These computing approaches can be developed in two ways; one is software and another is hardware approach. There is a need for explore all these methods and approaches collectively to taken in to consideration for the efficient implementation of the real-time applications with high accuracy and good result. This paper presents the survey on Real-time object detection, recognition and tracking systems for computer vision and machine vision systems through serial, parallel, hardware and software approaches and also it presents the different algorithms, methods, result analysis, limitations evaluation metrics and the best approaches for future research work.

Keywords: objects; detection; tracking; recognition; hardware; software, serial; parallel, FPGA.

1. INTRODUCTION

Machine vision and Computer vision are the two broad area where the image and video analytic operations being carried out. Machine vision is the technology is used to replace or complement manual inspection and measurement with digital camera and image processing [2]. It is the distinct field which provides imaging based automatic inspection, analysis, process controls, robotic guidance, and industrial product quality control and more [1][3]. Computer vision is another popular area where the image/video capturing, refining, processing, analyzing, understanding the images takes place. In both of these area; Object detection, recognition and tracking are the three important operations involved for many of the real time machine vision and computer applications [4]. At first, Object detection involves the extractions of information from the image or video, processing of the information and determining whether the object is present in the image or video frames or not [4]. Object detection operation is the important and base operation to perform other operations. Secondly, Object recognition is the process of recognition of known object and unknown objects is present in the image or video frames [5]. This operations mainly used for searching or recognition [5] of the particular object is present in the image or video frames. Finally, object tracking is the process of tracking the moment of the objects or to track the path of the objects in the video frame [6]. To perform these operations in real time machine vision and computer vision systems applications we need of high performance computing approach [4]; it may be hardware or software approach. There are many algorithms; methods are proposed for object detection, tracking and recognition [6][7], each approaches were implemented and tested with hardware and software. The following are the methods for object detection a). Frame difference, b). Optical flow, c). Background subtraction and many more [6][7], and then for object recognition methods are shape based, motion based, color based, texture based and more; finally object tracking is concern point based, kernel based and silhouette-based and more[6][7]. The above mentioned methods are implemented with hardware as well as software approach and achieve considerable result, but all these are consider only little bit care on to do power optimization, parallelization, accuracy and time consuming. There are some challenges need to face for successfully implementation of the object detection, tracking and recognition operations. To detect faces in in any image and video the following challenges like illuminant variations, dynamic moving scene, and others need to be consider while we implementing. For object tracking using faces we need to tackle the following challenges like dynamic moving objects, scaling of the objects and others; and finally for object recognition faces occlusion, image or video sizes, object orientation[] etc are the challenges.

This paper presents the various techniques, methods, algorithms which were used for object detection, tracking and recognition operations; and also discuss about the limitations, advantages and disadvantages of the various methods, future works, enhancements, performance evaluations, comparisons charts between the various methods. This paper is organized with many sections; in Section I, discuss about the hardware based object detection, software based object detection in parallel. In section II discuss about the object tracking through hardware as well as software approaches in both parallel and serial computing approach. In section III discuss about the object recognition method in hardware and software approach in parallel or serial. In section IV discuss about the comparisons with charts between the various methods, what we have discussed, finally the conclusion and future work being discussed.

2. OBJECT DETECTION RECOGNITION AND TRACKING CLASSIFICATION

This section discusses about the broad classification for object detection, tracking and recognition [31][32] and its sub classification. It is important to study and understand the various classification models to detect, track and recognition to choose which method is suitable for what and when. If we know these classifications clearly then only we can implement right application using right methods. Let us take an example of object detection [31][32]; background subtraction can be used for many applications implementation. Here we list out the various types and sub types for further analysis.

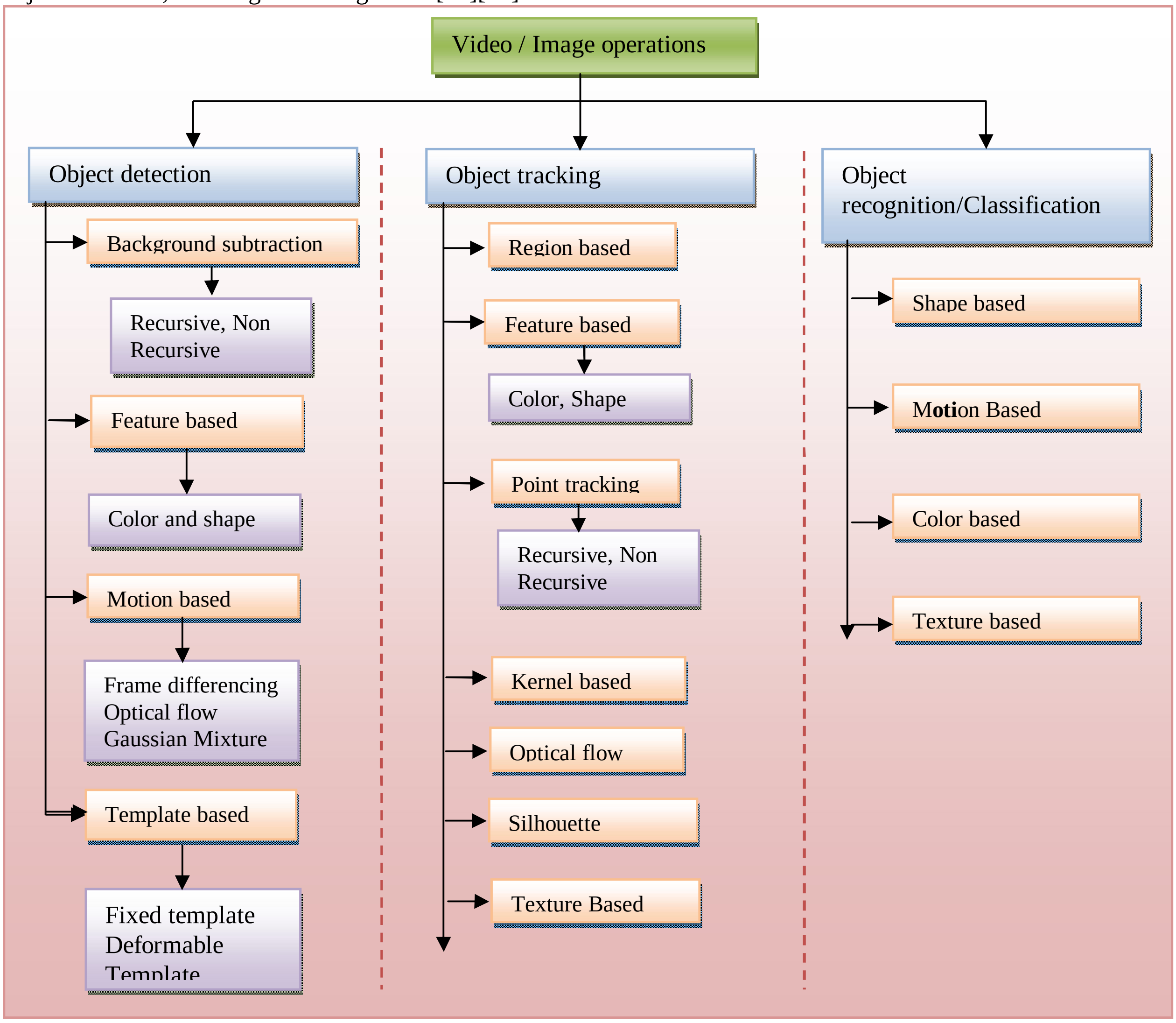

Fig. 1 Object detection, tracking and recognition classification

There are some advanced methods for object recognition, tracking and recognition were introduced. These methods are also listed in literature survey.

3. Literature Survey

3.1). Object detection, recognition and tracking in hardware based serial or parallel computing approach: the following were the related papers which deals about the object detection tracking and recognition in hardware based parallel computing approaches.

3.1.1). AdaBoost Based Object Detection

In[4] their work, they propoed and implemented generic, flexible parallel adaBoost based architecture for efficient object detection method. FPGA, and xilinx are the device and software used for this experiments. It was designed for detction several objects from up to 1024x768 size of images, and for video processing is concern it perform 64-139 frame per seconds. This proposed work used systoloc arrays of computarion to perform integral image calculation, and for up scaling of images and down scaling of the image can be done using image pramid concept. This parallel archicture was evaluated by using xlinx Vertex II pro FPGA. It is suitable for several type of budject and applications. Power optimization is left to future development. Fig. 3 shows the detection result of different applications for various sizes for image, feature sizes, frames and various objects.

3.1.2). Cascade Support Vector Machines

In [22], It proposed hardware architecture for acceleration of Cascade SVM used to desing intelligent embedded systems for online real-time calssification applications. It reduces the hardware resources and implemented using Spartan-6 field-programmable gate array (FPGA) platform and evaluated for object detection on 800 × 600 (Super Video Graphics Array) resolution images. It was boosted by nueral network to achives 40 frames per seconds. It achieves face detection ranges between 78% and 80%.

3.1.3). Support Vector Machines for 3D object recognition

Massimiliano pointil et al [33], in this proposed method, given a set of points which belong to either of two classes. One is linear and another is a non linear based on the hyperplane. Here they used linear SVM methos for 3D object recognition methods. It used 7200 images for 100 different objects were detected. It does not require feature exatraction and performance recognition on images regard as point of space of high dimention without estimations pose. It is well suited for aspect based recognition.

3.1.4). Adaboost algorithm with Modified Census Transform method

Dongkyun Kim et al[35], they proposed eye detection method based on the hardware. They developed a method for eye detection for various applications based on the adaBoost algorithm with modified census transform methods to detect eye on the images only not in the video sequences. It is parallelize hardware architecture method were introduced for eye detection with accuracy and downscaling the images are also done. it was implemented using FPGA and Verilog HDL. This method can detect eye with 0.15 ms with maximum estimated frequency of 106 MHz with expected 240 fps in VGA image. Here the detection rate achieved 93% however the detection rate may drop in glasses.

3.2). Object detection, recognition and tracking in software based serial or parallel computing or GPU approach

The following were the related papers which deals about the object detection, recognition and tracking in software based serial, parallel computing or GPU computing approaches.

3.2.1). Fuzzy Color Difference Histogram and Based Background Subtraction

In [23] Deepak Kumar Panda et al., The proposed works demonstrated on publically available various challenges video sequences such as Campus, Waving Trees, Water Surface, Curtain, Lobby and PETS2 006. The test sequences can be down- presented their work for detection of moving object with complex scene such as dynamic background, illumination variation, and camouflage. It proposed robust background subtraction technique with three important methods, firstly the Color Difference Histogram(CDH), it reducess no of false errors. Secondly, color difference is fuzzified with gaussion membership function. Finally, novel fuzzy color difference histogram, it reducess the large computation and also lession the intensity variation[23] it fails to detect shadow cast by the object and gave considerable performance. Hence, even though they used in industrial automotion, traffic monitoring and other real time systems need high speed computing, this draback leed to the development of the future work in parallel or GPU computing approach.

In [29], this approach is used to automatically tracking and detecting unusual suspecious moments in CCTV. This works based on the optain foreground object by subtracting background objects. It is classified people and inanimated objects, tracked realtime blob matching techniques and all object activities are classified using semantic based-approach. This approach gives real-time performance, adaptability, robustness against clutter, camera nonlinearities and eliminating machine learning based training methods.

In [26], new approach for video survilance object recognition algorithm were presented, based on shape feature, color histogram of the objects. The output for the recognition insensitive to the illuninamce, shadow, rotation and distance. This method adapted adaboost method and it gave considerable result.

In [27] Ning Liu, Hefeng Wu, and Liang Lin, they presented hierarchical background model, frame registration and object tracking are done in serial. There are some issues in the proposed work, firstly need for good automatic algorithm for different scenes. Secondly, Tracking feedback and CA should be feasible and flexible with parameters of different PTZ cameras. Need high speed background modeling algorithm for different tracking methods. This work was developed in serial computing platform using c++ and opencv. PTZ kind of object detection and tracking methods need high speed computing platform, this work left to the future development of high speed background modeling in software baser parallel or GPU based or parallel hardware based approach [27].

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3.2.2). Region of Interest and spacial and temporal exatraction

In [28], this work propose effective traffic survilance system for traffic vehicle classifying and counting at night time environments. This proposed work uses segmentation process based on the adaptive threshold to extract bright objects, then this will feed in to the spacial and temporal features fot the vehicle pattern extraction. It performed tracking and counting for vehicle video with 320x180 pixels size only. The vehicle type classification function can be further improved and extended by integrating some sophisticated machine learning techniques such as SVM and also further classified into such as buses, trucks, and light and heavy motorbikes etc

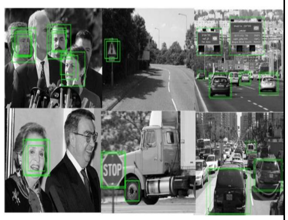
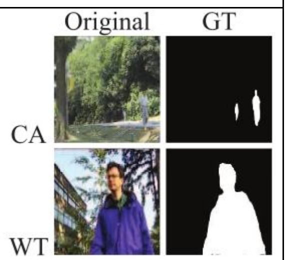
3.2.3). Viola-Jones casecade classifiers

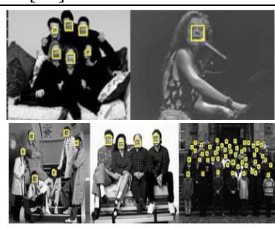
In [27], this work proposed object detection and recognition task done using Viola-Jones casecade classifiers. This work was implemented and parallel methodologies for integral image calculation, windows processing. Compared with the tradidinal CPU program and this approach achieves 22.42 times speed up for detection pahses and 1668.56 times speed up for recognition phase using NVIDA CUDA GTX 570 graphics card. It trained up to 2000 images testing 40 images with intel(i7 Processor) CPU. It gives good real time performance. This proposed work left to implementation of recognition using high end NVIDA kepler architecture and introduction new classified to perform detection and recognition more and more faster for the future development.

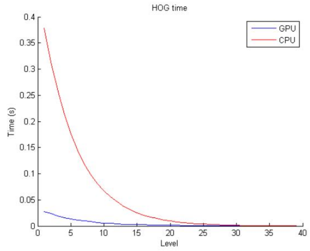
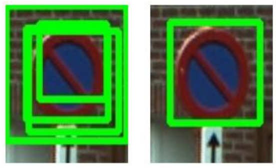
3.2.4) Histogram of Gradient and SVM

In [30], GPU based real time detection and recognition for 48 different signs. Histogram of Gradient method with optimized parallel algorithm using GPU system was used to detect the sign and to recognize, SVM was used. There were 32 scale level of processing recognition, for more accurate recognition SVM method was used. It achieves 27.9 fps with 1628x1236 resolution, detection rate is 91.69% and for recognition rate is about 93.77%. for future work,there is need for use of previous frame can be used to increase the performance.

TABLE-1.Sample Object Detection, Tracking, Recognition Methods, Experimental Result and Analysis

<table>
<tr><th>Methods, Concepts /Algorithm Used</th><th>Computational Time/ Frames per seconds, Image size, Tools used</th><th>Advantages and Disadvantages</th><th>Future works</th><th>Execution Result</th><th>Execution samples</th></tr>
<tr><td>[4] it usesd AdaBoost based object detection Algorithm, parallel systolic computation</td><td>64-139 fps, up to 1024x 768 image size, Xilinx Virtex II Pro FPGA</td><td>Flexible architecture used several types of applications</td><td>Power optimization, system level optimization, systolic array sizes, need development of processor for online training, dynamic and autonomous environments and situations</td><td>
<table>
<tr><th>Application /Accuracy</th><th>Input Image Size</th><th>Time to process 10 frames (seconds)</th><th>Projected Frame Rate</th></tr>
<tr><td rowspan="4">Face Detection 95-96 %</td><td>1024x768</td><td>0.109</td><td>~91</td></tr>
<tr><td>800x600</td><td>0.098</td><td>~102</td></tr>
<tr><td>640x480</td><td>0.084</td><td>~118</td></tr>
<tr><td>320x240</td><td>0.075</td><td>~133</td></tr>
<tr><td rowspan="4">Road Sign Detection 92-97 %</td><td>1024x768</td><td>0.099</td><td>~101</td></tr>
<tr><td>800x600</td><td>0.093</td><td>~107</td></tr>
<tr><td>640x480</td><td>0.083</td><td>~120</td></tr>
<tr><td>320x240</td><td>0.072</td><td>~139</td></tr>
<tr><td rowspan="4">Vehicle Detection 91-96 %</td><td>1024x768</td><td>0.128</td><td>~78</td></tr>
<tr><td>800x600</td><td>0.116</td><td>~86</td></tr>
<tr><td>640x480</td><td>0.108</td><td>~93</td></tr>
<tr><td>320x240</td><td>0.098</td><td>~102</td></tr>
</table>
In [4]</td><td>
in [4]</td></tr>
<tr><td>[23] Background subtraction with color difference histogram (CDH), color difference is fuzzified with a Gaussian membership, fuzzy color difference histogram (FCDH)</td><td>MATLAB, i5, 3.10 GHz, 4GB RAM,</td><td>CDH reduces the number of false errors, it fails to detect shadow cast by the object, industrial automation, traffic monitoring, security and surveillance</td><td>Need parallel processing to achieve performance</td><td>Average computation time per pixels in clocks
<table>
<tr><th>Algorithm</th><th>CA</th><th>WT</th><th>WS</th><th>CU</th><th>LO</th><th>PE</th></tr>
<tr><td>GMM</td><td>61380</td><td>52824</td><td>59024</td><td>62651</td><td>61194</td><td>61442</td></tr>
<tr><td>LBP</td><td>276458</td><td>251410</td><td>259997</td><td>274381</td><td>271002</td><td>287060</td></tr>
<tr><td>STLBP</td><td>296453</td><td>279682</td><td>283433</td><td>287742</td><td>304637</td><td>314650</td></tr>
<tr><td>LIBS</td><td>4185</td><td>19220</td><td>8990</td><td>23126</td><td>3968</td><td>4743</td></tr>
<tr><td>FBS</td><td>16027</td><td>17298</td><td>15779</td><td>15686</td><td>15376</td><td>14260</td></tr>
<tr><td>FST</td><td>1373300</td><td>1376059</td><td>1370386</td><td>1370076</td><td>1368588</td><td>1371471</td></tr>
<tr><td>MCC</td><td>266042</td><td>266879</td><td>265236</td><td>264864</td><td>265329</td><td>290532</td></tr>
<tr><td>FCH</td><td>140740</td><td>141174</td><td>140740</td><td>140616</td><td>140554</td><td>139872</td></tr>
<tr><td>FCDH</td><td>136245</td><td>136834</td><td>136059</td><td>136090</td><td>136059</td><td>135129</td></tr>
</table>
in [23]</td><td>

In [23]</td></tr>
<tr><td>[22], Cascade Support Vector machines, face detection</td><td>40 frames/s 800x600(SVGA) Spartan-6 field-programmable gate array (FPGA)</td><td>Used to desing online realtime classification Low cost parallel processor, tackle large scale problesm</td><td>Need to design >80 % for higher resoluton images</td><td>
<table>
<tr><th>Cascade Stages</th><th>Stage 1 (PPM)</th><th>Stage 2 (PPM)</th><th>Stage 3 (PPM)</th><th>Stage 4 (RPU)</th><th>Stage 5 (LBP & SPM)</th></tr>
<tr><td>Windows Processed</td><td>56984 (100%)</td><td>3025 (5%)</td><td>2334 (4%)</td><td>713 (1,2%)</td><td>228 (0,4%)</td></tr>
<tr><td>Rejection Rate</td><td>94,6%</td><td>22,8%</td><td>69,4%</td><td>76,4%</td><td>---</td></tr>
<tr><td>Cumulative Cycles</td><td>9</td><td>10</td><td>30</td><td>35</td><td>2697</td></tr>
<tr><td>Vectors per stage $N_{SV}(i)$</td><td>1</td><td>1</td><td>20</td><td>---</td><td>100</td></tr>
</table>
In [22]</td><td>
In [22]</td></tr>
</table>

<table>
<tr>
<td>[28], Region of interest based object detection and tracking for moving vehicle, Serial computing approach, segmentation process based on adaptive threshold, spatial and temporal features for identify and classify</td>
<td>30 frames/ s, dual core 2.4 GHz, 320x180 pixels size
C++ used for implementation
50 min video</td>
<td>Used for trackig and counting moving vehicle night time.
Perform only 320x180 pixel size, 97% achieved</td>
<td>Replace serial computation to parallel to get fast counting and classifying vehicle at night time</td>
<td><table>
<tr><th>Vahicles</th><th>Precision %</th><th>Recall %</th><th>F-Measure %</th></tr>
<tr><td>Cars</td><td>99.83</td><td>98.13</td><td>99</td></tr>
<tr><td>Motorbikes</td><td>91.30</td><td>90.5</td><td>90.90</td></tr>
<tr><td>Time span of the video</td><td>50 min</td><td>50 min</td><td>50 min</td></tr>
</table></td>
<td>
[28]</td>
</tr>
<tr>
<td>[30] Window-based Histogram of Gradient, SVM to classify sign</td>
<td>27.9 fps, pixels of 1,628 × 1,236 resolution, BelgiumTS Dataset, for detection 91.69 %, for recognition 93.77%
OpenCV-GPU based approach</td>
<td>capable of detecting and recognizing 48 classes of traffic signs in any sizes on each image frame, no information from previous frame are required, less detection and recognition accuracy</td>
<td>To increase detection and recognition accuracy and performance.
Need hardware based architecture for real time system</td>
<td></td>
<td></td>
</tr>
</table>

4.CONCLUSION AND FUTURE DIRECTION

This paper provided comprehensive survey of research on object detection, tracking and recognition categories for various approaches and also categorized the various general classifications for object detection, tracking and recognition based on serial, parallel computation, hardware and software based approach. With development of parallel computing it differ from sequential computing like GPU method. There has been tremendous changes have been made in object detection, tracking and recognition, but this method is suitable for limited size of memory can be used. Now a day all the computer was developed in multi core processor system this will increase and lead the parallel computing techniques. There also need for memory reconfigurable methods to do the above operations on the real-time system. The hardware based, and reconfigurable architecture is best suited for object detection, tracking, and recognition. There are many modern reconfigurable hardware description languages were introduced to do the video and image to design hardware architecture in parallel. There are number of scope for implementing image and video based reconfigurable hardware design for computer vision and machine vision applications.

REFERENCES

[1]. Machine Vision, Ramesh Jain, Rangachar Kasturi, Brian G. Schunck Published by McGraw-Hill, Inc., ISBN 0-07-032018-7, 1995

[2]. Machine vision introduction, SICK IVP Version 2.2, December 2006

[3]. By Bruce G Batchelor coming to terms with machine vision and Computer vision, http://ece631web.groups.et.byu.net/References /Machine- Computer%20Vision.pdf

[4]. Christos Kyrkou, Student Member, IEEE, and Theocharis Theocharides, Member, IEEE, A Flexible Parallel Hardware Architecture for AdaBoost-Based Real-Time Object Detection Christos Kyrkou, Student Member, IEEE, and Theocharis Theocharides, Member, IEEE IEEE TRANSACTIONS ON VERY LARGE SCALE INTEGRATION (VLSI) SYSTEMS, VOL. 19, NO. 6, JUNE 2011

[5]. Hsuan Lee, Chih-Yin Liu, Implementation of Real-time Object Recognition System for Home-Service Robot by Integrating , 2014 IEEE International Conference on System Science ang Engineering (ICSSE)

[6]. Himani S. Parekh, , Darshak G. Thakore , Udesang K. Jaliya A Survey on Object Detection and Tracking Methods, International Journal of Innovative Research in Computer 2014

[7]. Mrs J. Komala Lakshmi, , and Dr.M.Punithavalli, A Survey on Performance Evaluation of Object Detection Techniques in Digital Image Processing , IJCSI International Journal of Computer Science Issues, Vol. 7, Issue 6, November 2010

[8]. Guo Wei, Qi Qingwen and Jiang Lili, Zhang Ping, A NEW METHOD OF SAR IMAGE TARGET RECOGNITION BASED ON ADABOOST ALGORITHM 2008 IEEE

[9]. Junguk Cho, Bridget Benson, Shahnam Mirzaei, Ryan Kastner, Parallelized Architecture of Multiple Classifiers for Face Detection, 2009 20th IEEE International Conference on Application-specific Systems, Architectures and Processors

[10]. Masayuki Hiromoto, Student Member, IEEE, Hiroki Sugano, Student Member, IEEE, and Ryusuke Miyamoto, Member, IEEE Partially Parallel Architecture for AdaBoost-Based Detection With Haar-Like Features IEEE TRANSACTIONS ON CIRCUITS AND SYSTEMS FOR VIDEO TECHNOLOGY, VOL. 19, NO. 1, JANUARY 2009

[11]. Christos Kyrkou, Student Member, IEEE, and Theocharis Theocharides, Member, IEEE A Flexible Parallel Hardware Architecture for AdaBoost-Based Real-Time Object Detection, IEEE TRANSACTIONS ON VERY LARGE SCALE INTEGRATION (VLSI) SYSTEMS, VOL. 19, NO. 6, JUNE 2011 Kalyan Kumar Hati, Pankaj Kumar Sa, and Banshidhar Majhi, Intensity Range Based Background Subtraction for Effective Object Detection IEEE SIGNAL PROCESSING LETTERS, VOL. 20, NO. 8, AUGUST 2013

[12]. Jing-Ming Guo, Senior Member, IEEE, Chih-Hsien Hsia, Member IEEE, Yun-Fu Liu, Student Member, IEEE, Min-Hsiung Shih, Cheng-Hsin Chang, and Jing-Yu Wu, Fast Background Subtraction Based on a Multilayer Codebook Model for Moving Object Detection IEEE TRANSACTIONS ON CIRCUITS AND SYSTEMS FOR VIDEO TECHNOLOGY, VOL. 23, NO. 10, OCTOBER 2013

[13]. Bo-Hao Chen and Shih-Chia Huang, An Advanced Moving Object Detection Algorithm for Automatic Traffic Monitoring in Real-World Limited Bandwidth Networks IEEE TRANSACTIONS ON MULTIMEDIA, VOL. 16, NO. 3, APRIL 2014

[14]. Yao-Tsung Yang ,and Ching-Te Chiu, BOOSTED MULTI-CLASS OBJECT DETECTION WITH PARALLEL HARDWARE IMPLEMENTATION FOR REAL-TIME APPLICATIONS 2014 IEEE International Conference on Acoustic, Speech and Signal Processing (ICASSP) 2014

[15]. Ning Liu, Hefeng Wu, and Liang Lin, Hierarchical Ensemble of Background Models for PTZ-Based Video Surveillance, IEEE TRANSACTIONS ON CYBERNETICS, VOL. 45, NO. 1, JANUARY 2015

[16]. Pin Yi Tsai , Yarsun Hsu , Ching-Te Chiu , Tsai-Te Chu. Accelerating AdaBoost Algorithm Using GPU for Multi-Object Recognition 2015 IEEE

[17]. Hakki Can Karaimer, Ibrahim Cinaroglu, Yalin Bastanlar Combining shape-based and gradient-based classifiers for vehicle classification 2015 IEEE 18th International Conference on Intelligent Transportation Systems

[18]. George Kopsiaftis and Konstantinos Karantzalos VEHICLE DETECTION AND TRAFFIC DENSITY MONITORING FROM VERY HIGH RESOLUTION SATELLITE VIDEO DATA, IEEE 2015

[19]. Yuanyuan Wu, Student Member, IEEE, Xiaohai He, Member, IEEE, and Truong Q. Nguyen, Fellow, IEEE, Moving Objects Detection with Freely Moving Camera via Background Motion Subtraction 2015 IEEE

[20]. Polani Devi Vara Prasad, Janakani Devi Vara Prasad, Malijeddi Murali ADVANCED HARDWARE ARCHITECTUREFOR ADABOOSTBASED REALTIMEOBJECT DETECTION, International Journal of Advanced Research in Computer Engineering & Technology Volume 1, Issue 6, August 2012

[21]. Deepak Kumar Panda, Student Member, IEEE, and Sukadev Meher, Member, IEEE Detection of Moving Objects Using Fuzzy Color Difference Histogram Based Background Subtraction IEEE SIGNAL PROCESSING LETTERS, VOL. 23, NO. 1, JANUARY 2016

[22]. Christos Kyrkou, Member, IEEE, Christos-Savvas Bouganis, Member, IEEE,Theocharis Theocharides, Senior Member, IEEE, and Marios M. Polycarpou, Fellow, IEEE Embedded Hardware-Efficient Real-Time Classification With Cascade Support Vector Machines, IEEE TRANSACTIONS ON NEURAL NETWORKS AND LEARNING SYSTEMS, VOL. 27, NO. 1, JANUARY 2016

[23]. Deepak Kumar Panda, Student Member, IEEE, and Sukadev Meher, Member, IEE, Detection of Moving Objects Using Fuzzy Color Difference Histogram Based Background Subtraction IEEE SIGNAL PROCESSING LETTERS, VOL. 23, NO. 1, JANUARY 2016

[24]. Rasiq S.M, S.Krishnakumar Parallel Processors for High Speed Multiple Objects Recognition, 2014 IEEE

[25]. Ning Liu, Hefeng Wu, and Liang Lin Hierarchical Ensemble of Background Models for PTZ-Based Video Surveillance IEEE TRANSACTIONS ON CYBERNETICS, VOL. 45, NO. 1, JANUARY 2015

[26]. Jun Wu Zhitao Xiao , Video Surveillance Object Recognition Based on Shape and Color Features, 2010 3rd International Congress on Image and Signal Processing (CISP2010)

[27]. Ren Meng, Zhang Shengbing, Lei Yi , Zhang Meng CUDA-based Real-time Face Recognition System 2014 IEEE

[28]. Salvi, An Automated Nighttime Vehicle Counting and Detection System for Traffic Surveillance , 2014 International Conference on Computational Science and Computational Intelligence

[29]. Sandesh Patil Kiran Talele Suspicious Movement Detection and Tracking based on Color Histogram , 2015 International Conference on Communication, Information & Computing Technology (ICCICT), Jan. 16-17, Mumbai, India

[30]. Zhilu Chen and Xinming Huang, Zhen Ni and Haibo He, A GPU-Based Real-Time Traffic Sign Detection and Recognition System , IEEE 2014

[31]. Himani S. Parekh, Darshak G. Thakore , Udesang K. Jaliya A Survey on Object Detection and Tracking Methods, International Journal of Innovative Research in Computer and Communication Engineering Vol. 2, Issue 2, February 2014

[32]. Kirubaraj Ragland P. Tharcis, A Survey on Object Detection, Classification and Tracking Methods, International Journal of Engineering Research & Technology (IJERT) IJERT ISSN: 2278-0181 IJERTV3IS110458 www.ijert.org (This work is licensed under a Creative Commons Attribution 4.0 International License.) Vol. 3 Issue 11, November-2014

[33]. Pontil, M. ; Center for Biol. & Comput. Learning, MIT, Cambridge, MA, USA ; Verri, A. Support vector machines for 3D object recognition IEEE Transactions on Pattern Analysis and Machine Intelligence Jun 1998

[34]. Dongkyun Kim et al, An FPGA based parallel Hardware architecture for Real time eye detection, Journal of Semiconductor Technology and Science, June 2013

[35]. Shotton, J. ; Toshiba Corp. R&D Center, Kawaski ; Blake, A. ; Cipolla, R. Multiscale Categorical Object Recognition Using Contour Fragments, Pattern Analysis and Machine Intelligence, IEEE Transactions on (Volume:30 , Issue: 7)

[36]. Alvarez, J.M.A. ; Dept. of Comput. Sci., Univ. Autonoma de Barcelona, Cerdanyola del Valles, Spain ; Ĺopez, A.M. Road Detection Based on Illuminant Invariance Intelligent Transportation Systems, IEEE Transactions on (Volume:12 , Issue: 1)

[37]. Vinaykumar, M. ; Dept. of E.C.E., Nat. Inst. Of Technol., Warangal, India ; Jatoth, R.K. Performance evaluation of Alpha-Beta and Kalman filter for object tracking 2014 International Conference on Advanced Communication Control and Computing Technologies (ICACCCT),

[38]. Alper Yilmaz et al, Object Tracking: A Survey, ACM Computing Surveys, Vol. 38, No. 4, Article 13, Publication date: December 2006

[39]. Hiroyuki Ukida , High Speed and Wide Range Object Tracking System Using Pan-Tilt Cameras and Arm Robot IMTC 2005 - Instrumentation and Measurement Technology Conference Ottawa, Canada, May 17–19, 2005

[40]. Patricia P. Wang, Wei Zhang, Jianguo Li, Yimin Zhang REALTIME DETECTION OF SALIENT MOVING OBJECT: A MULTI-CORE SOLUTION 2008 IEEE

[41]. Dr. Arpita Gopal Sonali Patil Amresh Nikam, A parallel algorithm for outline capturing system for object recognition , 2010 IEEE