International Journal of Engineering Applied Sciences and Technology, 2016
Vol. 2, Issue 2, ISSN No. 2455-2143, Pages 34-36
Published Online December-January 2016 in IJEAST (http://www.ijeast.com)

FPGA BASED MOVING OBJECT TRACKING FOR INDOOR ROBOT NAVIGATION: A REVIEW

Mr. Tejas D. Magdum
Department of Technology
Shivaji University, Kolhapur,
Maharashtra, India

Prof. Pradip C. Bhaskar
Department of Technology
Shivaji University, Kolhapur,
Maharashtra, India

***Abstract*— Indoor environments such as houses, offices, hospitals, mobile robots have to be equipped with a capability to navigate in indoor environments to execute a given task while avoiding obstacles. A number of sensors are used widely in order to navigate while detecting obstacles in indoor environments. However, most of these sensors are too expensive to apply for low-cost service robots. Thus we can use low cost surveillance camera for indoor robot navigation using the visual navigation. This paper reviews the state of the art the FPGA and indoor robot navigation concept with the focus on FPGA based moving object tracking. The paper starts with an overview of FPGA in order to get an idea about FPGA architecture, and followed by an explanation on Moving object tracking algorithm, indoor robot navigation also provided in this paper. A literature reviews are highlighted in this paper with the focus on FPGA based object tracking with different application. Finally, we concluded FPGA is an ideal choice for implementation of visual navigation for real time moving object tracking algorithms.**

Keywords— **FPGA implementation, Indoor robot navigation, Moving object tracking algorithm**

I. INTRODUCTION

Moving object tracking is one of the fundamental components of computer vision; it can be very beneficial in applications such as unmanned aerial vehicle, surveillance, automated traffic control, biomedical image analysis, intelligent robots etc. The problem of object tracking is of considerable interest in the scientific community and it is still an open and active field of research.

Image processing is one of the major applications in embedded domain, which requires high effort in computation. In today's world most sensing applications require some form of digital signal processing. The two major contenders for signal processing hardware platforms are Digital Signal Processing (DSP) processor and Field Programmable Gate Array (FPGA). DSP processor offers high compute intensive, serial processing for complete System on a Chip (SOC) embedded product development, whereas FPGA offers highly flexible, parallel processing for a System on Programmable Chip (SoPC) development for proof of concept at formative stage of the system design, leading to manufacturable prototype at a later stage before the final Application Specific Integrated Chip (ASIC) implementation [1]. The FPGA contains logic components that can be programmed to perform complex mathematical functions making them highly suitable for the implementation of matrix algorithms. Therefore, FPGAs are an ideal choice for implementation of real time image processing algorithms.

II. MOVING OBJECT TRACKING

One of method of FPGA based image processing algorithms proposed for moving object tracking can be summarized as follows:

1. Median filter for image noise removal.
2. Back ground removal.
3. Thresholding to remove back ground static image.
4. Edge detection of motion object.
5. Computation of length-h and depth-v of the edge detected image
6. Computation of center at h/2 and v/2.
7. Overlay a block/cross-hair cursor image at the center.

With the advent of Micro-controllers, it is possible to design embedded image processing systems, which are portable, less power and time consuming. In micro-controller/DSP processors, the algorithm execution is sequential in nature. The speed of execution is greatly increased in advanced processors, which makes use of pipelined and super-scalar architectures. The advanced processors in corporates parallelism at instruction level, but the overall execution of the algorithm will be sequential in nature. Thus a micro controller based system cannot effectively utilize the inherent parallelism involved in most of the image processing algorithms. This imposes a limit on maximum processing rate. Thus such devices are not a suitable candidate for time critical applications.

International Journal of Engineering Applied Sciences and Technology, 2016
Vol. 2, Issue 2, ISSN No. 2455-2143, Pages 34-36
Published Online December-January 2016 in IJEAST (http://www.ijeast.com)

Field Programmable Gate Arrays (FPGA) on the other hand gives a platform for parallel execution. In an FPGA based design, a different hardware block executes the sequences of an algorithm in parallel, and thus provides quick response and high frame rate. Since the overall operations are performed in less number of clock cycles, the power consumption will be reduced considerably, compared to micro-controller/DSP-processor based designs.

III. INDOOR ROBOT NAVIGATION

Mobile service robots in indoor environments such as houses, offices, hospitals, are introduced widely. These mobile robots have to be equipped with a capability to navigate in dynamic environments to execute a given task while avoiding obstacles. A number of sensors such as laser finders, ultrasonic sensors, stereo-camera-based range sensors, and etc. are used widely in order to detect obstacles in natural environments. However, most of these sensors are too expensive to apply for low-cost service robots like vacuum cleaning robots or guide robots [2][7]. Hence, visual navigation takes much attention after web cameras were introduced a few years ago since its cost is attractive comparing with the previous sensors.

Generally GPS system is used for both indoor and outdoor navigation. But GPS system has some limitations, first is it requires costly infrastructure like navigation satellite and GPS module. Here navigation satellite is used as position monitoring equipment. We can use indoor surveillance camera as position monitoring equipment for indoor visual navigation application.

Thus we can use low cost camera for indoor robot navigation using the visual navigation.

IV. LITERATURE REVIEW

Several implementations of object tracking on FPGA platform exist. Also there are several implementation of indoor positioning or navigation system using the cameras. Also there are novel implementations of mobile service robots in indoor environments such as houses, offices, hospitals. Here some literature survey's mentioned as below.

I. SOFIA NAYAK, SHASHANK SEKHAR PUJARI, "MOVING OBJECT TRACKING APPLICATION: FPGA AND MODEL BASED IMPLEMENTATION USING IMAGE PROCESSING ALGORITHMS" [1]

In this paper, implemented image processing modules using Simulink logic entities and introduced into the video chain established on TERASIC DE2 FPGA hardware evaluation kit. The video source is from PAL/NTSC compatible camera and the output display is on 640X480 resolution VGA monitor. The functional implementation of all processes are done using ALTERA QUARTUS-II tool. The image processing algorithms used are,

(a) Noisy video generation with random motion
(b) Video image median filter
(c) Video image back ground removal
(d) Video image thresholding
(e) Video image edge detection
(f) Video image height and width calculation
(g) Video image center computation
(h) Video image and center image overlay.

The image processing algorithms are developed initially by Model Based Design Approach using Simulink models of MATHWORK's MATLAB Tool. Then these algorithms are implemented on ALTERA CYCLONE-II FPGA device using TERASIC DE2 FPGA hardware kit and ALTERA QUARTUS-II software tool. The input video image is taken from a NTSC/PAL camera and processed in real time using the algorithms on the FPGA and the resulted tracked video image output is displayed on a VGA monitor.

II. NGUYEN XUAN DAO, BUM-JAE YOU, SANG-ROK OH, "VISUAL NAVIGATION FOR INDOOR MOBILE ROBOTS USING A SINGLE CAMERA" [2]

In this paper proposed a novel visual navigation method by combining visual localization with the extraction of valid planar region using only single video camera. Here visual localization approach is used with a landmark model of 2 lines and a point using single video camera. The method has advantages of easy detection and tracking the simple landmark model. Only two pairs of natural line and point are used for the visual localization to take the advantage of fast detection. To track a given landmark model, Lucas-Kanade optical flow algorithm is applied by using gradient descent. Here odometer data combined with visual information to determine the height of the landmark features. On-ground image features are used to calculate the homograph between two image frames and to detect the planar region for navigation. Experimental results of this 6proposed method show the robustness of the method with respect to image illumination and noises.

III. SUHAS JADHAV, ROHIT NARVEKAR, AJAY MANDAWALE, SACHIN ELGANDELWAR, "FPGA BASED OBJECT TRACKING SYSTEM" [3]

In this paper proposed an object tracking system based on FPGA using canny edge detection Algorithm. The system consists of canny edge detection algorithm implemented on FPGA kit to identify edges of real time object. Also a tracking and reorganization of object is done by Smartphone camera. Canny edge detection algorithm is key stage in image processing and object recognizing application. The field programmable gate array contains logic components that can be programmed to perform complex mathematical functions making them highly suitable for the implementation of matrix algorithm. Individual frames acquired from the target video are fed into the FPGA. These are then subject to segmentation,

threasholding, filtering stages. Following these the object is tracked by comparing the background frame and the processed updated frame containing the new location of the target.

IV. **MONOJ PANDEY, DOROTHI BPRGOHAIN, GARGI BARUAH, J.S. UBHIAND KOTA SOLOMON RAJU, "REAL TIME OBJECT TRACKING: SIMULATION AND IMPLEMENTATION ON FPGA BASED SOFT PROCESSOR" [4]**

In this paper implemented "Kernel based Mean Shift Algorithm" on Xilinx Spartan-6 FPGA board using EDK for tracking a moving object. They simulated in MATLAB first and then implemented on Micro-blaze soft-processor based FPGA board. Here tracking is observed for two similar objects crossing each other moving with uniform speed in a stored video as well as real time video.

V. **M. SANDEEP RAO, ARANIND NATARAJAN, S. MOORTHI AND M. P. SELVAN, "REAL TIME OBJECT TRACKING IN A VIDEO STREAM USING FIELD PROGRAMMABLE GATE ARRAY", [5]**

In this paper Implemented object tracking in a live video stream using 32 bit RISC soft-core processor embedded on FPGA. The HSV color model is used to make the algorithm robust to changing lightening scenario; in addition, the compute expensive Color-Space transformation module is implemented. The algorithm used to track a moving object using averaging, dynamic thresholding and center-of-mass model for updating the current location of the target object.

VI. **JUNG UK CHO, SEUNG HUN JIN, XUAN DAI PHAM, DONG KYUN KIM, AND JAE WOOK JEON, "FPGA BASED REAL TIME VISUAL TRACKING SYSTEM USING ADAPTIVE COLOR HISTOGRAMS" [6]**

In this paper described a real time visual tracking circuit using adaptive color histograms which is based on pattern matching algorithms where the appearance of the target is compared with a reference model in successive images and the position of the target is estimated. These are implemented on FPGA.

VII. **SHASHANK PUJARI, SHEETAL BHANDARI, SUDARSAN CHANDAK, "FPGA CONTROLLED VISION SYSTEM FOR SURVILLANCE ROBOT (UAV)", [7]**

In this paper described a cost effective FPGA based implementation of UAV (Unmanned Aerial Vehicle) flight control and object tracking system. The designed model is useful for UAV development and which have the importance in aerospace engineering Computing and Communication.

VIII. CONCLUSION

In this paper we have described moving object tracking algorithms and its review on FPGA based implementation, also we have described indoor robot navigation and literature review. After the all discussion we can conclude that the FPGA is ideal choice for implementation of moving object tracking algorithm based visual navigation

IX. REFERENCES

[1] Sofia Nayak, Shashank Sekhar Pujari, "Moving Object Tracking Application: FPGA And Model Based Implementation Using Image Processing Algorithms" International Conference on Computing Communication Control and Automation 2015.
[2] Nguyen Xuan Dao, Bum-Jae You, Sang-Rok Oh, "Visual navigation for indoor mobile robots using a single camera".
[3] Suhas Jadhav, Rohit Narvekar, Ajay Mandawale, Sachin Elgandelwar, "FPGA Based Object Tracking System", Fifth International Conference on Communication Systems and Network Technologies 2015.
[4] Monoj Pandey, Dorothi Bprgohain, Gargi Baruah, J.S. Ubhiand Kota Solomon Raju, "Real Time Object Tracking : Simulation and Implementation on FPGA Based Soft Processor", ICSSITE, 2013.
[5] V. M. Sandeep Rao, Aranind Natarajan, S. Moorthi and M. P. selvan, "Real Time Object Tracking in a video Stream using Field Programmable Gate Array", IEEE, 2012.
[6] Jung Uk cho, Seung hun jin, Xuan Dai Pham, Dong kyun Kim, and jae wook Jeon, "FPGA Based Real Time Visual Tracking System using Adaptive color Histograms", IEEE, 2007.
[7] Shashank Pujari, Sheetal Bhandari, Sudarsan Chandak, "FPGA Controlled Vision System for Survillance Robot (UAV)", CSI Communication, Robotics, Nov. 2008, Vol32.
[8] Girish Chap Ie, R. D. Daruwala, "Design of Sobel Operator based Image EdgeDetection Algorithm on FPGA" International Conference on Communication and Signal Processing, April 3-5, 2014, India.
[9] R. C. Gonzalez, R. E. Woods, Digital Image Processing. 3rd ed. Prentice Hall, 2007, pp. 187-190.
[10] Sreejith m, "Development of an FPGA based Image processing intellectual Property core" May 2014.
[11] Chunzhong Chen, Baofeng Guo, Xiangwei Wu, "An Edge Detection Method for Hyperspectral Image Classification Based on Mean Shift", The 2014 7th International Congress on Image and Signal Processing
[12] Hayato Hagiwara, Kenichi Asami, and Mochimitsu Komori, "Real-time Image Processing System by Using FPGA for Service Robots", IEEE Global Conference on Consumer Electronic 2012.
[13] Ingrid Nunes Rodrigues, Charles Luiz Silva de Melo, Vanessa Mello da Frota Botinelly and Jozias Parente de Oliveira, "FPGA hardware architecture with parallel data processing to detect moving objects using the background image subtraction technique".
[14] Fire Bird V research platform hardware and software manual.