

Research Article

Moving Object Tracking with OpenCV on ARM Cortex-A8 in surveillance Applications

B.Dhananjaya*, B. Rama murthy† and P.Thimmaiah†

†Dept. of Electronics, Sri Krishnadevaraya University, Anantapur, A.P, India.

Accepted 22 March 2015, Available online 29 March 2015, Vol.5, No.2 (April 2015)

Abstract

Video tracking in real time is one of the most important topics in the field of surveillance systems. Detection and tracking of moving objects in the video scenes is the first step in the information extraction in many computer vision applications. In this paper, an intelligent method for object detection and tracking in real time video using OpenCV on ARM-9 Beagle Bone Black is explored. Processing a video stream to segment foreground objects from the background is a critical step in many computer vision applications. Background subtraction is a commonly used method for achieving this segmentation. Gaussian Mixture-based Background Segmentation Algorithm and morphological operations are used in this paper for object detection and tracking. In the first step a video is taken as input, is divided into frames, each frame is converted to binary frame then applying background subtraction algorithm to detect the moving objects. Erosion and Dilation Morphological operations are performed on these frames to remove the unwanted shadow, tracking and labeling the moving objects. The main processing unit is a ARM Cortex A8 processor based Beagle Bone Black (BBB) with Linux (Ubuntu) operating system installed with OpenCV. The indexing of identified objects and automatic labeling enables the developed system suitable for surveillance applications.

Keywords: Background subtraction, OpenCV, ARM - Cortex, Morphological Operations, Object tracking, surveillance.

1. Introduction

Moving Object detection and tracking is the process of segmenting a particular area of interest from the different frames and tracking its movement (S.M.Subramanian, 2013). The idea of object tracking in videos can be used in the areas of vehicle navigation, video surveillance, video games, automobile driver assistance, robotics, biometrics and in the field of medical science.

With the increasing advancement in technology, there is a growing concern for safety and security everywhere. To address this concern, the number of surveillance cameras has also increased. The collected data is nevertheless difficult to store and monitor manually on a continual basis. There are several approaches to do this job without human intervention. The underlying principle of all these methods is to detect, segment and track objects in the live video.

A static camera observing a scene is a common case of a surveillance system. Detecting moving objects is an important and essential step in analyzing the scene. A usual applicable assumption is that the images of the scene without the moving objects exhibit some regular behavior that can be well described by a statistical

approach. If we have a statistical model of the scene/frame, a moving object can be detected by spotting the frames of the video that don't fit the model. This process is commonly known as "background subtraction".

OpenCV (Xianghua Fan, 2012), an open source library for image processing and Computer vision applications, is having the predefined library of various Background subtraction methods (Piccardi.M, 2004). Installing of OpenCV in Linux environment is very easy and simple. So in this research OpenCV is chosen as the software platform on Ubuntu which is to be loaded in Beagle Bone Black.

The rest of the paper is organized as follows: Section 2. The Block diagram of the research work done, 3. Software Implementation, 4.Features of the Hardware Involved 5.Working Principle, 6. Output Result, 7. Conclusion and Future Scope.

2. Block diagram

In this research Beagle Bone Black (S.M.Subramanian, 2013) development Board is the main hardware platform, which is like a small palm size computer. The features of this board will discuss in section 4. A key board and Mouse is connected using USB HUB as the

*Corresponding author: B.Dhananjaya

board is having only one USB Host .One HDMI monitor is connected to display the output result. The Ubuntu Linux operating system is loaded in the Micro SD card (Min 8GB) and is inserted in to the SD slot provided in the Board. The board is powered up using a 5V, 2mA adaptor.

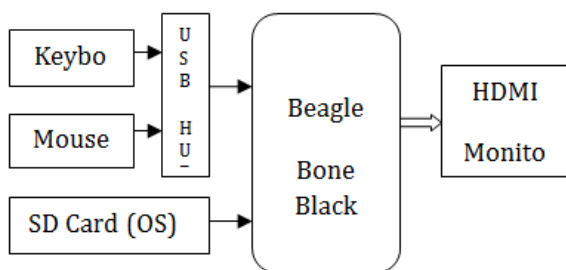


Fig 1 Block diagram

3. Software Implementation

3.1 Linux Operating System

An operating system (OS) is a piece of software that acts as an interface between user and computer . The purpose of an OS is to provide an environment where a user can execute programs. Basically operating systems are of 2 types, single-user OS (eg: DOS, Windows), Multi-user OS (eg: LINUX ,UNIX).

The Linux system can be distributed, used and expanded free of charge. Linux is freely available Multi tasking operating system. Developers have access to all the source codes, thus being able to integrate new functions easily and also to find and eliminate programming bugs quickly. Linux has a kernel – programming interface. The kernel is the heart of the Linux operating system .Linux is Portable , Multitasking system, provides a Hierarchical file system with built in security ,

Ubuntu is built on the foundation of Linux; which is a member of the UNIX family. UNIX is one of the oldest types of operating systems and has provided reliability and security in professional applications for almost half a century.

3.2 OpenCV

OpenCV (open Source Computer Vision Library) (Xianghua Fan , 2012) (Md. Syadus Sefat , 2014) is a library of collection of functions mainly focused at real time computer vision applications. It is a cross platform based library. It focuses mainly on image/video processing applications or algorithms.

General Description

- Open Source computer vision library in C/C++.
- Optimized and intended for real time applications.
- Generic image/video loading, saving and acquisition.

- Both low and high level API

Features

- Image data manipulation (allocation, release, copying, setting, conversion).
- Image and video I/O (file and camera based input , image/video output)
- Matrix and vector manipulation and linear algebra routines(products , solvers , eignvalues)
- Various dynamic data structures (lists, queues , sets, graphs).
- Basic Image processing (filtering , edge detection, sampling and interpolation , morphological operations etc)
- Structural analysis (Connected components, contour processing, distance transform, template matching, line fitting, ellipse fitting etc).
- Camera calibration (finding and tracking calibration patterns, calibration, homographic estimation etc).
- Image labeling (line, conic, polygon, text drawing).

In this research Linux Ubuntu 12.04 OS installed with OpenCV 3.0 Beta recently released version of Opencv is taken.

4. Hardware Implementation

4.1 Beagle Bone Black (BBB)

Beagle Bone Black (Ch Srikanth, 2014) is a small palm sized Desktop Computer platform which can be run using many Operating systems.

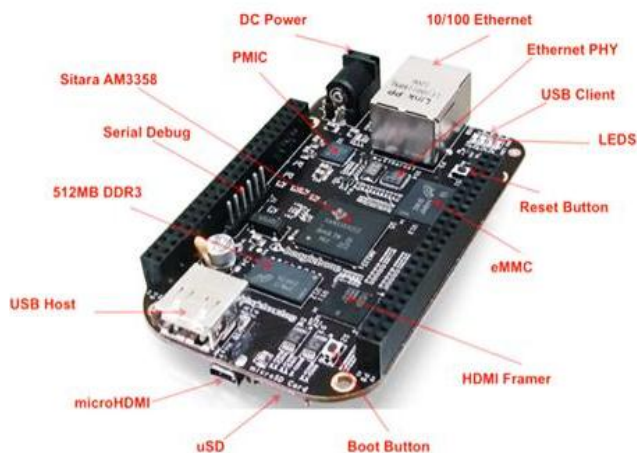


Fig 2 Beagle Bone Black

Beagle Bone Black development board has the following features shown in Fig 4 and the block diagram of BBB is shown in fig 3.

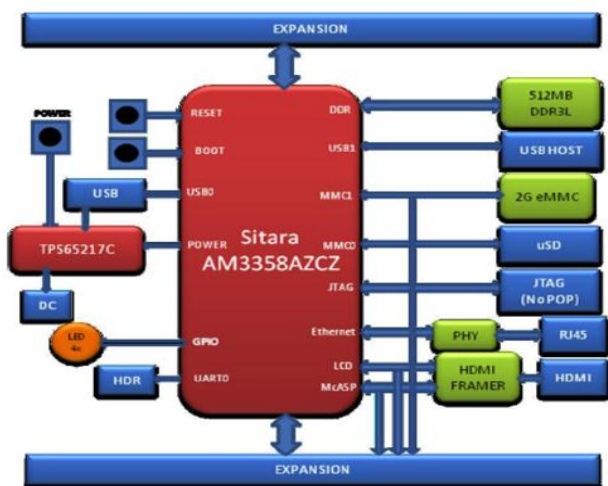


Fig 3 Block Diagram of BBB

This Beagle Bone Black development Board is boot up with Ubuntu operating system preloaded in to the Micro SD (8GB min) card which is inserted in to SD slot. For Display purpose a HDMI monitor is connected to this Board using a Micro HDMI to HDMI converter. As this board is provided with only one USB Host , a USB HUB is used to connect Key board ,Mouse and also USB Camera if require in future (The Display is only for the Demo purpose).

Operating Systems	Linux, Android, Windows Embedded CE, QNX, ThreadX	MMC/SD	3
Standby Power	7 mW	CAN	2
ARM CPU	1 ARM Cortex-A8	UART (SCI)	6
ARM MHz (Max.)	275,500,600,800,1000	ADC	8-ch 12-bit
ARM MIPS (Max.)	1000,1200,2000	PWM (Ch)	3
Graphics Acceleration	1 3D	eCAP	3
Other Hardware Acceleration	2 PRU-ICSS, Crypto Accelerator	eQEP	3
On-Chip L1 Cache	64 KB (ARM Cortex-A8)	RTC	1
On-Chip L2 Cache	256 KB (ARM Cortex-A8)	I2C	3
Other On-Chip Memory	128 KB	McASP	2
Display Options	LCD	SPI	2
General Purpose Memory	1 16-bit (GPMC, NAND flash, NOR Flash, SRAM)	DMA (Ch)	64-Ch EDMA
DRAM	1 16-bit (LPDDR-400, DDR2-532, DDR3-400)	IO Supply (V)	1.8V(ADC),3.3V
USB Ports	2	Operating Temperature Range (C)	-40 to 90

Fig 4 Features of BBB

5. Background Subtraction Algorithm

Background subtraction is a major step in many real time vision based applications (Brutzer S, 2011). We can take some examples like visitor counter where a camera in fixed position takes the number of visitors entering or leaving the room, in another case a traffic camera placed aside on roads extracting the information of the vehicles etc. In all these cases, the

first is nothing but extract the person or vehicle alone i.e extract moving foreground from static background.

An image of a room without visitors or persons, image of a road without vehicles etc, we can consider as background image. Whenever we want to identify moving object subtract the new image with background image, will get the foreground objects alone. But In most of the cases we don't find any such background images easily so we have to extract the background from whatever images we have. In some cases along with vehicles or persons their shadow is also moving, which will identify as foreground object when we subtract new image from background. This is one of the complicated case to remove the shadow.

Most of the background subtraction algorithms assume that every observed video sequence F is made of a static background K, therefore background subtraction algorithms can be summarized using the formula

$$X_t(s) = \begin{cases} 1 & \text{if } d(I(s,t), B_s) > \text{Thr} \\ 0 & \text{Otherwise} \end{cases} \quad (1)$$

Where $X_t(s)$ is the background pixel, $d(I(s,t), B_s)$ is the foreground mask denoted by $I_{s,t}$ (Intensity) at B_s (background pixel) and Thr is the threshold value.

The detailed description of different methods in background subtraction algorithm is given in the previous paper (B. Dhananjaya, 2015). OpenCV has given three of such algorithms which are very easy to use. They are

- BackgroundSubtractorMOG (P. Kadew TraKu Pong, et al, 2002)
- BackgroundSubtractorMOG2 (Z.Zivkovic, 2004, 2006)
- BackgroundSubtractorGMG (Andrew B. Godbehere, 2012)

In this research Gaussian Mixture – based Background/Foreground segmentation Algorithm (Z.Zivkovic, 2004, 2006) is used. In this algorithm it selects the appropriate number of Gaussian distributions for each pixel, this is one of the most important feature of this algorithm. the basic difference of the all these 3 algorithms is , in first one the Gaussian distribution is applied throughout the algorithm , in second case only appropriate number of Gaussian distributions are applied , in third case combines statistical background image estimation and per- pixel Bayesian segmentation is applied.

6. Implementation Procedure

In this paper the proposed algorithm will work for both online and offline videos, This paper describes the implementation for offline videos. The step by step flow of implementation procedure is given in Fig 5. This paper is continuation of ongoing research work (B. Dhananjaya, 2015) towards realizing embedded system.

In the initial step a .avi format video is taken and is placed in the drive where the output file is present. AVI stand for Audio video Input. The moving object in a static video in which the background is constant is implemented in this paper. Each moving object is detected and tracked in this research.

- In the initial stage the video is split in to frames. A single frame is read at a time.
- Resizing the image to what extent we require. (Resizing to 320x240 pixel size in this).
- Image blurring is applied to the frame in the next step.
- In blurring or smoothing operation a filter to an image is applied . the most common type of filters are linear, in which an output pixel's value (i.e g(i,j)) is determined as a weighted sum of input pixel values (i.e f(i+k,mj+l)).

$$g(i, j) = \sum_{k,l} f(i+k, j+l)h(k, l) \tag{2}$$

h(k,l) is called the kernel.

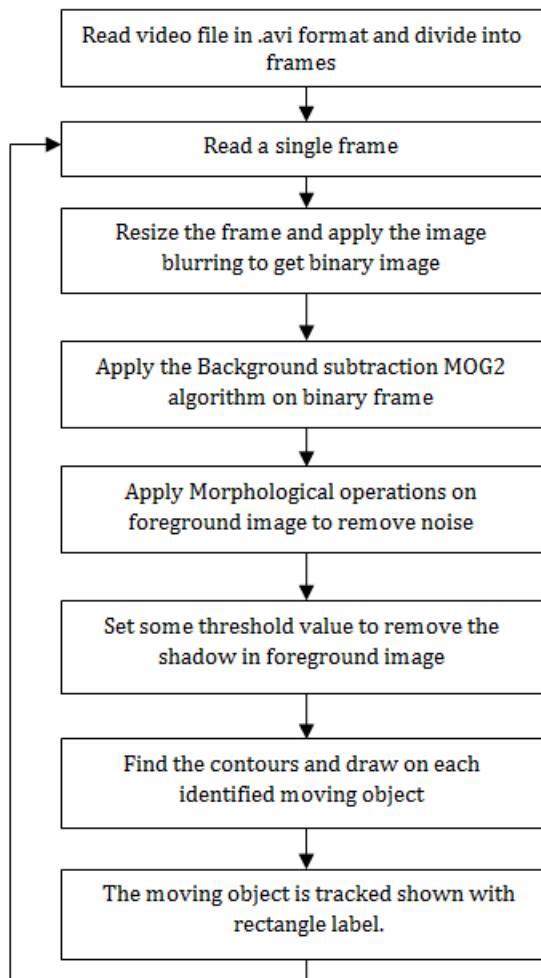


Fig 5 Flow of Implementation

- After blurring the image, the background subtraction algorithm is applied with require threshold value.

- The morphological operations like erosion and dilation are applied on output frame of the background subtraction i.e foreground image to remove the noise in the image.

In Erosion , erodes the source image using the specified structuring element that determines the shape of a pixel neighborhood over which the minimum is taken

$$dst(x, y) = \min_{src(x+x1, y+y1)} \tag{3}$$

(x1,y 1): element(x1,y 1) ≠ 0

In Dilation, dilates the source image using the specified structuring element that determines the shape of a pixel neighborhood over which the maximum is taken

$$dst(x, y) = \max_{src(x+x1, y+y1)} \tag{4}$$

(x1,y 1): element(x1,y 1) ≠ 0

- Then a threshold value is set to remove the unwanted shadow in the frame. The thresholding operation can be expressed as

$$dst(x, y) = \begin{cases} \maxValifsrc(x, y) > thr \\ 0otherwise \end{cases} \tag{5}$$

So, if the intensity of the pixel src(x,y) is higher than thr threshold) , then the new pixel intensity is set to a maxVal. Otherwise , the pixels are set to 0.

- Contours identified on each detected moving object and are drawn.
- A rectangular label is applied on each tracked object.

7. Output result

In this research .avi format pre recorded video is taken as input, resizing each frame, converted to binary by applying image blurring. The background subtraction algorithm is applied and on resulted foreground image morphological operations are applied to remove the noise. A proper threshold value is set to remove the shadow. Moving objects are detected in the foreground image, contours (Guobo Xie, et al, 2013) are identified, to track the moving objects a red color rectangular label is drawn on each moving object shown in the Fig 6.6.

The proposed BackgroundsubtractorMOG2 (Z.Zivkovic, 2004), algorithm is applied on a video of 120 frames with frame rate of 8 frames per second, having each frame size of 320x240 pixels.



Fig 6.1 Complete setup

A complete setup is shown in the Fig 6.1, the Beagle bone black with HDMI Display, keyboard and Mouse.



Fig 6.2 Input image

Above image is a frame read from input video in which we can observe three cars are moving. The background of this is shown in Fig 6.3.

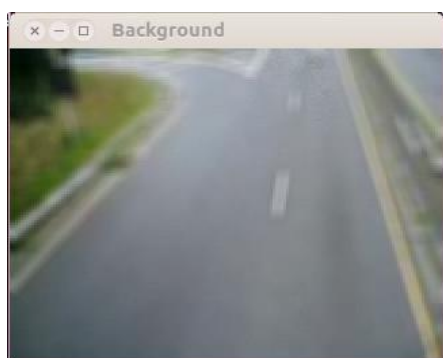


Fig 6.3 Background

After applying the background subtraction algorithm foreground and background images are extracted from the input frame. Fig 6.4 shows the foreground image.

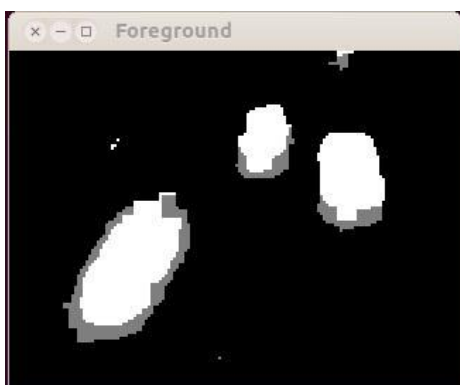


Fig 6.4 Foreground Image

In the foreground image we can observe that the three moving cars are detected using the background subtraction algorithm. The above image is resulted after application of morphological operations like erosion and dilation.

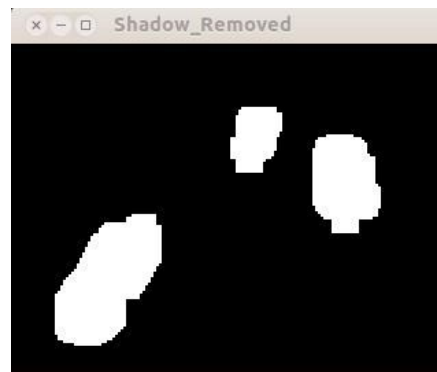


Fig 6.5 Image without shadow

A threshold operation is made with value of 200 for 255, to the foreground image then all the shadows will be removed and the resulted image is shown in Fig 6.5.

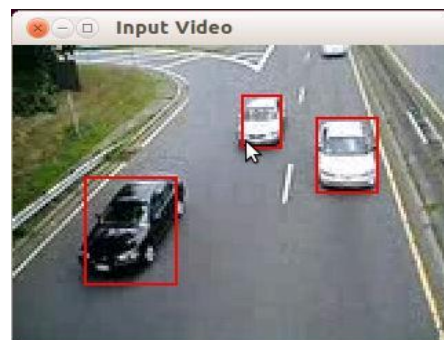


Fig 6.6 Output Image with rectangle label on Moving Objects

After removing the shadows in the foreground image, contours are found and are drawn. the rectangular label shows the tracking of moving objects (cars in this case) , and this label follows the moving objects till that object is in the vicinity of camera as shown in the Fig 6.6 (if we add camera in future).

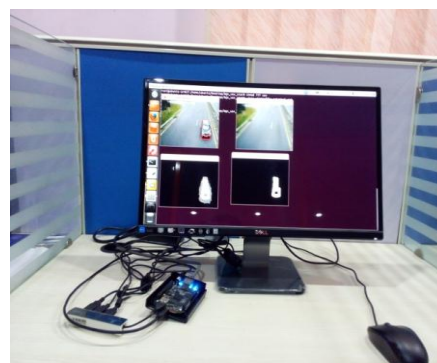


Fig 6.7 Implementation Setup

The Fig 6.7 shows a complete implementation setup in which when we execute the application program through command prompt of Linux , all the four windows respectively input video, background, foreground and shadow removed image are displayed .

8. Applications

8.1 UAV surveillance

UAVs or Unmanned Aerial Vehicle is an unmanned aircraft. They are either remote controlled or can fly autonomously based on inbuilt plans or complex automation systems. They are mainly used in military applications. Their main role comes into picture during attack where it is too risky for humans to venture. They are sometimes also used as police observation vehicles in crime scenes.

8.2 Indoor Monitoring system

The proposed algorithm can be used to monitor indoor surveillance. As the real time noise level is expectedly minimized in closed door situation and it will work better and the rate of getting false alarm may be significantly lower. Therefore with lesser noise, changing ambient light and increased efficiency, this technique can be used indoor.

8.3 Traffic

Fixing the cameras a head of the junctions and counting number of vehicles from each side and processing all sides of the junctions and adjust the timing for each side of the junction based on the traffic density.

Conclusion and Future Scope

An intelligent Gaussian Distribution based background subtraction algorithm using OpenCV library on Beagle bone black for UAV surveillance systems is presented. Comparison previous research (B. Dhananjaya, 2015) using MATLAB this paper is showing a complete algorithm implementation on Embedded hardware platform. OpenCV is the best library for image or video processing applications. Beagle bone black is low cost embedded hardware platform which is having very good features.

This work is part of ongoing research to realize embedded video processing platform for surveillance applications. The work is aimed to be continued in processing detecting smaller size objects in higher frame rate live videos.

Acknowledgements

I sincerely thank staff of Electronics department of Sri Krishnadevaraya University, for their support in this research work.

References

- B. Dhananjaya, (2015), Moving Object detection in aerial videos for object extraction and tracking in UAV Applications, *International Journal of Computer Applications*. Volume - 112, page no. 37-42
- Z.Zivkovic, (2004), Improved adaptive Gaussian mixture model for background subtraction, *ICPR*, Volume -8, page no. 28-31.
- Z.Zivkovic, (2006), Efficient Adaptive Density Estimation per Image Pixel for the Task of Background Subtraction, *Pattern Recognition Letters*, Volume -27, page no.773-780.
- P. KadewTraKuPong and R. Bowden, (2002), An improved adaptive background mixture model for real-time tracking with shadow detection, *Springer US*, Page no.135-144.
- Andrew B. Godbehere , (2012) , Visual Tracking of Human Visitors under Variable-Lighting Conditions for a Responsive Audio Art Installation, *American Control Conference (ACC)* , Page no.4305-4312.
- S.M.Subramanian, (2013), Moving Object Tracking in video Scenes Embedded Linux platform, *IJEAT*, ISSN:2249-8958 , Volume 3 , Issue-2.
- Md. Syadus Sefat, (2014), Implementation of vision based intelligent home automation and security system, *3rd International conference on informatics, electronics & vision*, page no. 1-6.
- Ch Srikanth, (2014), Smart Embedded medical Diagnosis using Beaglebone Black and Arduinio, *IJETT*, Volume 8 , page 1.
- Piccardi.M.(2004). Background Subtraction techniques: A review. *IEEE International Conference on Systems, Man and Cybernetics*, Volume 4, page no. 3099-3104.
- Xianghua Fan , (2012), The system of face detection based on OpenCV, *Control and Decision Conference (CCDC)*, page no. 648-651.
- Brutzer S, (2011), Evolution of Background subtraction techniques for video surveillance, *Computer Vision and Pattern Recognition (CVPR)*, page no 1937-1944.
- Guobo Xie and Wen Lu , (2013) , Image Edge Detection Based on OpenCV , *International Journal of Electronics and Electrical Engineering* ,Volume 1 , Page No 2.