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# Video Processing on an ARM Based Embedded System

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## ABSTRACT

One of the many applications of embedded systems is remote image/video acquisition for surveillance purposes. In the recent times, ARM processor and LINUX OS have become more popular in the embedded space with the availability of a number of libraries. In this paper OpenCV library and two cameras interfaced to an ARM development board are used for implementing the surveillance system. Video from more than one camera will provide better information for applications such as intrusion detection. ARM cortex-A8 processor based Beagleboard-xM with interfaces such as USB, DVI-D, S-Video, Ethernet, HDMI, LED and so on, is an ideal platform for low power embedded application development. Angstrom Linux distribution has the necessary device driver are supported by a flexible GNU cross compilation tool chain for application development. The environment supports both C and C++ programming. The primary objective of the paper is to display the processed video on the graphics display .The ARM based embedded system was interface with two cameras for video capturing. Video frames were capture at 10 frames/ second instead of 30 frames/second to conserve memory on the embedded system.

**Keywords:** OpenCV, ARM, BeagleBoard-xM, USB, DVI-D, LINUX, S-Video, HDMI, LED, DM3730, DSP, OMAP3530, MLL

## I. INTRODUCTION

Embedded system have become integral part of our lives and they offer specific and cost-effective solutions to many of our day-to-day needs. Particularly the recent advancements in the design, architecture and integration of ICs along with the evolution of interface standards have opened up many avenues for the implementation of embedded systems. ARM has now-a -days evolved as a de-facto processor while Linux has matured into a light weight and fast enough OS for the embedded systems. BeagleBoard-xM is one development platform with embedded Linux from Texas Instruments (TI) DM 3730 processor architecture. The DM3730 processor is characterized by the presence of an asymmetric dual-core architecture, which including an ARM and a DSP along with a shared memory between them. The BeagleBoard-xM is an open source hardware single-board computer with a full set of Open Source tools. Angstrom distribution is an optimized embedded Linux environment meant for the BeagleBoard platform. This Linux distribution is much stable, and is widely adapted and supported by the open source and development community on internet. OpenCV is an open source computer vision library that runs on multiple platforms, including the combination of ARM and Linux, is known for its computational efficiency and strong focus on real-time applications.

Single camera based embedded systems are widely in use for surveillance applications. Images or video from a single camera may not be accurate always as the quality would differ for different light conditions and distances. If multiple cameras, say two of them,

along with application of appropriate image processing techniques, are used it would be possible to capture significant details and get depth perception. In video base surveillance systems, challenge is also to process voluminous information that was captured, while large amount of memory is needed on the capturing system.

The primary intent of this paper is to get exposure to embedded Linux, understand the architecture of the ARM cortex-A8 processor, leveraging on the features of the operating system and processing application for use in surveillance requirements.

The initial steps performed in this paper involve installation of the Angstrom distribution of Linux on the target BeagleBoard platform, followed by setting up of the toolchain for the cross compilation and then the installation of OpenCV library on the Ubuntu based development system. The implementation involve interfacing of two cameras to the platform and development of video capturing and processing software. Video frames were captured at 10 frames/second to conserve memory space and reduce processing time as well as complexity on the embedded system. The resolution chosen for the video frames is 320x240 pixels. The processed video output of the system can be viewed by connecting a graphics display through the HDMI port or S-Video output of the platform. Facedetection, water marking and gray scaling of the color video streams from the cameras are the video processing implemented in the current work.

## II. RELATED WORK

Anumol Jose, Bibin Jose, Dinu L.D, Jomon John, Sabarinath G proposed a paper, "Implementation and Optimization of Embedded Face Detection System" This paper also gives a clear picture on BeagleBoard-xM ,it is a new low-cost low-power platform based on the Texas Instruments (TI) DM 3730 processor architecture. The DM3730 processor is characterized by the presence of an asymmetric dual-core architecture, which including an ARM and a DSP along with a shared memory between them. OpenCV is a famous open source computer vision library developed by Intel corporation was utilized for some of the algorithms. Comparative results for the different platforms are introduced and analysed with an emphasis on real-time Application [1] .

Pramod Poudel and Mukul Shirvaikar published a paper, "Optimization of Computer Vision Algorithms for Real Time Platforms". This paper presents work on performance optimization of common computer vision algorithms such as correlation on embedded systems. The correlation algorithm which is popular for face recognition, can be implemented using convolution or the Discrete Fourier Transform (DFT). The algorithms are benchmarked on the Intel Pentium processor and Beagleboard, which is a new low-cost low-power platform based on the Texas Instruments (TI) OMAP 3530 processor architecture. The OMAP processor consists of an asymmetric dual-core architecture, including an ARM and a DSP supported by shared memory. OpenCV, which is a computer vision library developed by Intel corporation was utilized for some of the algorithms. Comparative results for the various approaches are presented and discussed with an emphasis on real-time implementation [2] .

Wang Jing and He Huiming proposed a paper "ARM-based Embedded Video Monitoring System Research" This IEEE paper explain that the embedded system is a special computer system with strict requirements for functionality, reliability, cost, size, and power consumption. This paper also describes about the video monitoring based on ARM, which gives an idea to bring about various images on a single LCD screen by mounting a digital camera [3].

Yan Liping and Song Kai, " Design and Realization of Image Processing System Based on Embedded Platform", This paper gives new idea of developing an image processing system on embedded platform, which is designed and implemented with S3C2410 for the core processor, ARM Linux for the operation

system platform and MiniGUI for graphical user interface. The hardware architecture is introduced and the design, realization and the operation of the software system is described in detail. The testing result indicate that the embedded image processing system is running well, and can display image on the board [6].

Michal Sedlak published a paper, "Simulation of 2D physics of objects captured by web camera using OpenCV and Box2D" This paper presents one approach to simulation of physics applied on objects captured by web camera. It utilise OpenCV library for image capturing and contour detection. Objects detected by OpenCV are reconstructed from its outlines in Box2D environment so the physics can be applied to it. Because of restrictions of Box2D, approximation and scaling of outlines and tessellation of objects is done using with Delaunay triangulation algorithm [7].

## III. SYSTEM OVERVIEW

### A.Embedded platform

The BeagleBoard-xM is a pocket-sized reference board containing a Texas Instruments Open Multimedia Application Platform (OMAP) 3 system-on-a-chip (SoC) processor, which includes an ARM Cortex-A8 core, Texas Instruments C64x+ digital signal processor (DSP), and on-board graphics engine, as well as integrated dual data rate (DDR) random-access memory (RAM). The BeagleBoard is an inexpensive platform for hobbyists, academics, and professionals who are learning Linux and small systems. The best option for Beagleboard is Linux, mainly because there is an active project supporting Beagleboard which includes working drivers, a good toolchain (GCC based) and many common packages ready to build and install into Beagleboard.

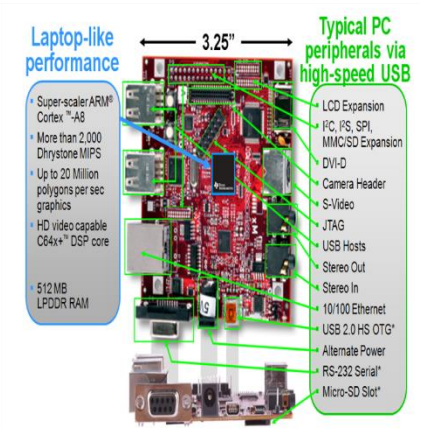


**Figure 1.** Hardware Specification of BeagleBoard-xM

### B.OpenCV

OpenCV is an open source computer vision library of programming functions mainly aimed at real time computer vision developed by Intel Corporation. The library can be written in C and C++ and runs under Linux, Windows and Mac OS X. There is active development on interfaces for Python, Ruby, Matlab, and other languages. OpenCV was designed for computational efficiency and with a strong focus on real-time applications. OpenCV can be written in optimized C and can take advantage of multicore processors. If the library finds Intel's Integrated Performance Primitives on the system, it will use these proprietary optimized routines in many algorithmic areas.

The main aim of OpenCV's is to provide a simple computer vision infrastructure that helps people to build sophisticated vision applications. The OpenCV library contains over 500 functions that covers many areas in vision, including factory product inspection, medical imaging, security, user interface, camera calibration, stereovision, and robotics. OpenCV also contains a general-purpose Machine Learning Library (MLL).This sublibrary is focused on statistical pattern recognition and clustering. The MLL is highly useful for the vision tasks that are at the core of OpenCV's mission, but it is generally used for any machine learning problem. OpenCV has got so many usage in image processing and has been

tools for engineering students and researchers across the world for their researches.

Computer vision has found widespread acceptance in mobile applications like video streaming, smart cameras, vehicle navigation, smart traffic light systems, and virtual reality.

## IV. RESULTS AND DISCUSSION

The phase one of the paper involved the study and understanding of the features of BeagleBoard-xM followed by installation of Angstrom Linux OS environment on the board. The subsequent steps involved exploration for the right toolchain for the cross compilation and the GNU toolchain from CodeSourcery was identified and installed on the Ubuntu 16.04 based development system. The OpenCV library and CMake packages were installed on the development system.

The phase two of the paper involved implementation of video capturing and processing appplications for capturing of videos at low frame rate, simultaneous capturing of videos from two cameras, facedetection, watermarking and gray scaling.

The RS232 cable is used for the serial communication between the windows based PC, which was used as the tty console, and the target board. The RJ45 cable is the Ethernet cable used to network the target board with the development system. The camera's were connected through the USB ports. The Target board is also connected to the development system via USB for communication as well as powering the board.

A graphics terminal is connected to the target board using an HDMI or S-Video cable. The setup is shown in the figure2.

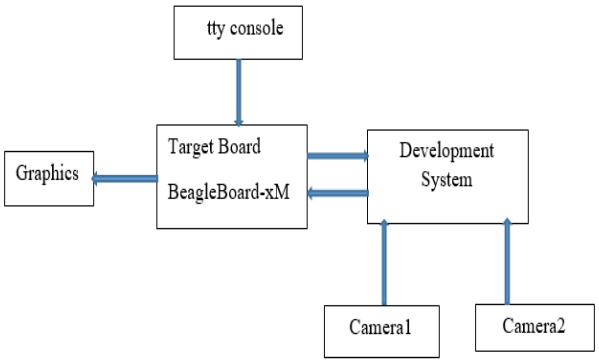


**Figure 2.** Project Setup

The raw and processed video are saved on SD card. The cameras are connected to the system and the compiled code is made to run, so that the processed video is displayed on the graphics terminal. Using the 'ipconfig' command/application two IP addresses are assigned to the development system and the target board. The cross complied executables could be uploaded to the target board from the development system. It is also possible to remotely log-in and execute the executable from the console of the development system.

### A. Video Processing

**Face detection:**

A recognition process is more efficient if it is based on the detection of features that encode some information about the class to be detected. This is similar to Haar-like features that encode the existence of oriented contrasts between regions in the image. A set of these features can be used to encode the contrasts exhibited by a human face and their spacial relationships. Haar-like features are so called because they are computed similar to the coefficients in Haar wavelet transforms.The object detector of OpenCV has been initially proposed by Paul Viola and improved by Rainer Lienhart. First, a classifier (namely a cascade of boosted classifiers working with haar-like features) is trained with some sample views of a particular object (i.e., a face or a car), called positive examples, that are scaled to the same size (say, 20x20), and negative examples - arbitrary images of the same size. After a classifier is

trained, it can be applied to a region of interest (of the same size as used during the training) in an input image. The classifier outputs a "1" if the region is likely to show the object (i.e., face/car), and "0" otherwise.

### B.Watermarking:

Is a standard industry practice to embed in the video recording "text" for safeguarding IP rights as well as incorporating additional information such as title, date, time, place etc of the video recording.

### C. Gray Scaling

Gray scaling the color content is a standard video processing technique employed to help highlighting /inferring specific information. In this approach of video processing, each of the RGB values are multiplied with standard "weights" and then added to arrive at the corresponding value in the gray scale.

### D. Project Results

An embedded image acquisition and processing system which can be used as a remote host on a net for the web access of acquired images has been implemented. The software implemented could be used for displaying the images acquired and stored, on a pen drive which is interfaced through an USB port, on the color LCD screen of the embedded system.


**Figure 3.** Overall setup of project

**Figure 4.** Output Face Detection

## V. CONCLUSION and FUTURE WORK

An ARM based embedded system was interfaced with two cameras for video capturing. Video frames were captured at 10 frames/second to conserve memory on the embedded system. Video processing algorithms for gray scaling and face detection were implemented as possible used cases for surveillance applications. A very powerful yet light weight OpenCV library was identified for use in embedded image processing systems. The system has significant spare processing power and memory available, which could be used in future for implementing complex video compression and processing applications .Current work stopped with the generation of 2 separate low frame rate videos. The next steps could be stitch the two videos together and implement advanced algorithms for real-time detection of intrusions etc for realizing an efficient and effective Surveillance system. Interfacing an IR camera and/ or a different sensor to the system could add diversity of information acquisition of the system.

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