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A Review on Real Time Embedded Video Processing On Raspberry Pi Using Open CV & PiCamV2

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***Abstract*—Paper The paper presents a study of existing methods for motion and face detection algorithms and their application to the on-board miniature Raspberry Pi computer. The algorithms realized by OpenCV functions were modified to optimize their operation on the mentioned platform, which could be used as an embedded surveillance system. The paper also mentions the training of a custom classifier for hand detection, what could be further used as a basis for detecting hand gestures.**

***Index Terms*— OpenCV, Raspberry Pi, motion detection, cascade classifiers, video surveillance, video Processing.**

I. INTRODUCTION

The paper deals with the design of an embedded surveillance system realized on a Raspberry Pi 3 B minicomputer. The work's main part focuses on the study of selected functions used by modern surveillance systems, like motion detection methods and issues [1] and algorithms used for detecting human faces [2]. After selecting the proper methods, they are developed in the programming language C/C++ in way to exploit the computational power of the embedded minicomputer. An external web-camera captures static scenes which are used as input data for the image processing algorithms. These algorithms analyze the images in real time, yielding information about the moving objects and saving the video sequence if a motion has occurred. To automatize these tasks, basic Computer Vision approaches [3] are modified and applied to the real-time camera feed. The functions are provided by OpenCV (Open Source Computer Vision), what is an open source library containing over 500 optimized algorithms for image and video analysis and manipulation. It has C++, C, Python, Java and MATLAB interfaces and supports Windows, Linux, Android and Mac OS [4]. The functions are completely designed with the help of OpenCV libraries and are optimized to operate effectively on the Raspberry Pi platform.

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A. Video Processing

In electronics engineering, video processing is a particular case of signal processing, in particular image processing, which often employs video filters and where the input and output signals are video files or video streams. Video processing techniques are used in television sets, VCRs, DVDs, video codecs, video players, video scalers and other devices. For example—commonly only design and video processing is different in TV sets of different manufactures.

Video processors are often combined with video scalers to create a video processor that improves the apparent definition of video signals. They perform the following tasks:

- deinterlacing
- aspect ratio control
- digital zoom and pan
- brightness/contrast/hue/saturation/sharpness/gamma adjustments
- frame rate conversion and inverse-telecine
- color point conversion (601 to 709 or 709 to 601)
- color space conversion (YPBPR/YCBCR to RGB or RGB to YPBPR/YCBCR)
- mosquito noise reduction
- block noise reduction
- detail enhancement
- edge enhancement
- motion compensation
- primary and secondary color calibration (including hue/saturation/luminance controls independently for each)

Some of the first applications of digital video and image processing were to improve the quality of the captured images, but as the power of computers grew, so did the number of applications where video and image processing could make a difference.

B. Open CV

OpenCV (Open source computer vision) is a library of programming functions mainly aimed at real-time computer vision. Originally developed by Intel, it was later supported by Willow Garage then It seize (which was later acquired by Intel). The library is cross-platform and free for use under the open-source BSD license. In other word OpenCV (Open Source Computer Vision Library: http://opencv.org) is an open-source BSD-licensed library that includes several hundreds of computer vision algorithms. The document describes the so-called OpenCV 2.x API, which is essentially

a C++ API, as opposed to the C-based OpenCV 1.x API (C API is deprecated and not tested with "C" compiler since OpenCV 2.4 releases). OpenCV has a modular structure, which means that the package includes several shared or static libraries. The following modules are available:

• Core functionality (core) - a compact module defining basic data structures, including the dense multi-dimensional array Mat and basic functions used by all other modules.

• Image Processing (imgproc) - an image processing module that includes linear and non-linear image filtering, geometrical image transformations (resize, affine and perspective warping, generic table-based remapping), color space conversion, histograms, and so on.

• Video Analysis (video) - a video analysis module that includes motion estimation, background subtraction, and object tracking algorithms.

• Camera Calibration and 3D Reconstruction (calib3d) - basic multiple-view geometry algorithms, single and stereo camera calibration, object pose estimation, stereo correspondence algorithms, and elements of 3D reconstruction.

• 2D Features Framework (features2d) - salient feature detectors, descriptors, and descriptor matchers.

• Different layers of video transmission and storage each provide their own set of formats to choose from.

• For transmission, there is a physical connector and signal protocol (see List of video connectors). A given physical link can carry certain display standards that specify a particular refresh rate, display resolution, and color space.

• Many analog and digital recording formats are in use, and digital video clips can also be stored on a computer file system as files, which have their own formats. In addition to the physical format used by the data storage device or transmission medium, the stream of ones and zeros that is sent must be in a particular digital video coding format, of which a number are available (see List of video coding formats).

C. Motion Detection

The easiest way to determine a motion in a video sequence is to compare any two consecutive frames in it. This method is called motion detection based on frame difference, and is further described here [5]. In the case of a constant background, the content of the frames are the same, except in the region of moving objects. The processed images are taken from the camera feed. After conversion to gray-scale format, a function calculating the absolute difference returns an output image highlighting the actual motion. A basic segmentation method separates this region and corresponding functions remove the pixel noise.

• Object Detection (objdetect) - detection of objects and instances of the predefined classes (for example, faces, eyes, mugs, people, cars, and so on).

• High-level GUI (highgui) - an easy-to-use interface to simple UI capabilities.

• Video I/O (videoio) - an easy-to-use interface to video capturing and video codecs.

• ... some other helper modules, such as FLANN and Google test wrappers, Python bindings, and others.

• Advance vision research by providing not only open but also optimized code for basic vision infrastructure. No more reinventing the wheel.

• Disseminate vision knowledge by providing a common infrastructure that developers could build on, so that code would be more readily readable and transferable.

• Advance vision-based commercial applications by making portable, performance-optimized code available for free – with a license that did not require code to be open or free itself.

D. Programming Language

OpenCV is written in C++ and its primary interface is in C++, but it still retains a less comprehensive though extensive older C interface. There are bindings in Python, Java and MATLAB/OCTAVE. The API for these interfaces can be found in the online documentation. Wrappers in other languages such as C#, Perl, Ch, Haskell,[15] and Ruby have been developed to encourage adoption by a wider audience.

E. Video Formats

• Analog video

Analog video is a video signal represented by one or more analog signals. Analog color video signals include luminance, brightness (Y) and chrominance (C). When combined into one channel, as is the case, among others with NTSC, PAL and SECAM it is called composite video. Analog video may be carried in separate channels, as in two channel S-Video (YC) and multi-channel component video formats.

• Digital video

• Digital video signal formats have been adopted, including serial digital interface (SDI), Digital Visual Interface (DVI), High-Definition Multimedia Interface (HDMI) and DisplayPort Interface .*Figures*

II. TRADITIONAL METHODS

In the paper, the basic issues and solutions of embedded video processing for computer vision were presented. The Raspberry Pi computer and several functions from the OpenCV project was used. The ROI selecting and rectangle merge functions significantly increased the overall frame per second ratio of the system. The achieved modifications of the basic video processing algorithms made possible the operation of a surveillance system on the on-board minicomputer. [1]

In this paper, an embedded real-time video monitoring system is designed; the embedded web streaming server is based on the Linux Operating System. It succeeds in network video monitoring. The system has low-cost, good openness and portability and is easy to maintain and upgrade. Here the web

browser is based on MJPG streamer for streaming captured video from camera placed in remote location. [2]

Author have designed a smart surveillance system capable of recording/capturing video/image and transmitting to a smart phone and ftp server. It is advantageous as it offers reliability and privacy on both sides. It is authenticated and encrypted on the receiver side also. Hence it offers only the person concerned to view the details. Necessary action can be taken in short span of time in the case of emergency conditions like intrusion. IOT approach offers an alternate means to design a reliable Security system compared to conventional CCTVs. The upfront cost of the systems is potentially lesser compared to conventional systems. Thus, a security monitoring system controlled by Raspberry Pi has been implemented and tested. The power electronics part of the system and the underlying Python code script were optimally designed/coded, realized and tested. [3]

This project can easily be applied to places that need constant monitoring because Raspberry pi forms the basis of the project. Raspberry is cheap, offers a lot of technical possibilities and can be supplied from many locations. It works to simultaneously monitor the contents, temperature, and humidity of a room where it is installed. Many places, such as a cold food storage facilities, children's rooms, and summer homes can be monitored. No special program is required and the web browser on a mobile phone or computer is sufficient. A missing feature of the project is that it does not have a database. [4]

The paper includes the initial works done for the development of a system that aims to dictate a much larger scale of the voting frontier. Thus the machine still has many limitations that need to be overcome to allow it to reach the level it is aimed for. Starting with the devices integrated in the machine, for large scale production and use the devices need to be upgraded to better or alternate versions. The fingerprint sensor that was previously used had a low threshold for the output confidence level and overall low efficiency, and so the Adafruit fingerprint sensor is an improvement on those levels. However, the fingerprint sensor used has a limit on the memory storage as the fingerprints obtained are stored in its internal memory. [5]

In this paper, an embedded real-time video monitoring system is designed; the embedded web streaming server is based on the Linux Operating System. It succeeds in network video monitoring. The system has low-cost, good openness and portability and is easy to maintain and upgrade. Here the web browser is based on MJPG streamer for streaming captured video from camera placed in remote location. The MJPG streamer is cross-compiled and loaded in to the Raspberry pi board to act as a web streaming server. [6]

In this phase of the project, a secure connection, with the help of VOIP and SIP protocol, was established between two Raspberry Pi devices with a Wi-Fi connection. With the help of this connection, voice was recorded, played and streamed on and from one Raspberry Pi to another raspberry pi module using a Python based GUI successfully. The attempt to live video and audio transmission between two raspberry pi modules was successfully achieved through VOIP server/client implementation maintaining operation of Raspberry Pi as a headless embedded system. The usage of open source, freeware programs and OS kept the project cost low. [7]

Raspberry Pi has enough power for HD video and image manipulation, and can be connected to the Arduino board. Connected to Raspberry Pi, Arduino can be used as a control unit while Raspberry Pi processes video images. Raspberry Pi features include Bluetooth and Wi-Fi wireless technologies and this is the shortcut to display images directly on the Android device. [8]

In this paper we have discussed the outline and execution of a multifunction image processing system on a Raspberry pi 2 model. Multifunction which are performed on Raspberry pi are Conversion of Color image into Binary and grey scale image, rotation of image, mirror image. Image processing using Raspberry pi based is the new concept and advance technology which can open an era of computer vision. Other gestures and distinctive sort of image processing systems can be implemented in raspberry pi which will dramatically reduce the price of the system. Therefore, here conclude that the Raspberry pi module can be easily replace with a host processor for any kind of real time image processing applications. [9]

Author implemented the algorithm to enhance an image in different enhancement degree using the raspberry pi. It was found that the algorithm developed for the raspberry pi executes successfully and gives a very colorful image. [10]

This paper describes object tracking application and its implementation using different designs with rotating camera. This paper also proposes two different algorithms for rotation of the camera according to data given by the object detection algorithm. This paper also describes study and features of different object tracking algorithms in application. This implementation can be expanded for multiple object tracking as well. With static camera multiple objects can be detected and tracked as long as they are in the line of sight of the camera. But with a moving camera multiple objects can be detected and any one object can be tracked. Multiple cameras can be used to detect and track multiple objects. The cameras can be synchronized to detect and track different objects. [11]

The structure of video capture system based on S3C2440processor is presented. Video 4 Linux is used to get the camera video data, which is transferred to the Web Server lighttpd, and the data is displayed on the client browser or on client. The monitoring system based on the embedded platform has advantages of small size, longer work time and stable performance. It is widely recognized and becoming the main flush of network remote monitoring system. [12]

Thus, we have designed a smart supervisor system capable of capturing video/image and device operation like temperature, human motion, motor on/off transmitting to a smart phone/tablet. It is advantageous as it offers reliability and privacy on both sides. It is authenticated on the receiver side;

hence it offers only the person concerned to view the details. Necessary action can be taken in short span of time in the case of emergency conditions such as elderly person enter the restricted area, military areas, smart home system, offices, industries, railway station, Banks etc., Future work is to locate the number of persons located exactly on that area and their position so that accurate information can be obtained on the receiver side. [13]

Raspberry Pi is an innovative technology. The sheer number of users and fan base support the fact that the device can see an abundant future ahead. The device can certainly help anyone who really needs to learn electronics and computers. Raising the processing power can certainly assist the product in the future. Also supply a case and an appropriate instruction manual will get better the product. Also at present Windows operating systems are not compatible because of the ARM processor. If the processor is enhanced or any workaround is found to run Windows directly on the Raspberry Pi then it can be a great step for the Pi. The Raspberry Pi is a wonderful piece of hardware because of the combination of the features of a traditional computer and an embedded device. It supports computer operating systems like Linux and provides easy input/output lines i.e. the GPIO makes it ideal for controlling almost anything. Programming the GPIO is much simple and perceptive then a traditional FPGA or microprocessor. Lastly it can be said that Raspberry Pi can be efficiently used if its processing power is kept in mind. It can work as an individual computer but cannot swap it. [14]

Raspberry PI is useful for small application development because it can be used to integrate with many components such as speakers, LED lights, sensors, cameras and wireless communication units to develop smart applications. In this project, two ZigBee modules is being communicated with two different devices (laptop and raspberry PI). With the successful communication implementation, it can be further developed by adding sensors to develop smart applications such as smart alarm system, population of customer walk-in and walk-out, temperature alert system and so on. This project also demonstrates how files are being shared between raspberry pi and windows users. Raspberry PI acts as server by using samba. Samba was chosen because it is free software and enables admin to configure for file access to protect the privacy or personal information of a company. It is very important to protect the file in order to maintain data consistency and accuracy. [15]

III. CONCLUSION

In the paper, the basic issues and solutions of embedded video processing for computer vision were presented. The Raspberry Pi computer and several functions from the OpenCV project was used. The ROI selecting and rectangle merge functions significantly increased the overall frame per second ratio of the system. The achieved modifications of the basic video processing algorithms made possible the operation of a surveillance system on the on-board minicomputer. The analysis and testing of frontal face detection algorithms was completed and in addition, a custom LBP classifier for hand and palm detection was trained. The amount of positive images used for the training process was not sufficient, but the classifier could be upgraded by adding more samples.

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