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Fast and Cost Efficient Face Detection System with CNN Using Raspberry PI

Pravin Kumar.S, Bhuvaneswari Balachander

Abstract: ***Face detection is an important process when it comes to computer vision. It will serve as an input to a Facial expression and Face recognition system. Modern "C.C.T.V" cameras with face detection features are costly and only few are connected to the internet. This paper proposes a Face detection system which detects faces with a fusion of Convolutional neural network and Gabor Filter. Gabor filter is used to extract important facial features and Convolutional neural network is used to train the model. Model weights files are executed in Raspberry PI which is cost efficient. Raspberry pi is connected to cloud service which will alert the user with SMS and E-mail.***
Keywords: Convolutional Neural Network, Cloud Service, Face Detection, Gabor filter, Raspberry Pi

I. INTRODUCTION

The core concept of Face detection [1] is to give computer an ability to find human faces in a video or an image seamlessly. Over the years numerous algorithms have been proposed and developed to improve the face detection efficiency. Human brains can instantly recognize and detect faces but when it comes to computers there is always a challenge. Face detection systems are affected by extreme lightening, pose variation, and large variation in faces. Face Recognition [2] is used widely in Biometrics scanner and security system. Especially in biometrics faces of an individual are matched to the existing ones in the database. Important facial features are extracted in the first stage of an algorithms, there are modifications done in feature extractions and algorithms to improvise the efficiency of the detection. Computers and Embedded systems which detect faces are widely used in variety of applications like identity verification. criminal identification, security systems.

A. Face Detection: Algorithm finds faces in a given input such as Video or Images for faces, and then the faces are cleaned with various filters for further processing.

B. Face Recognition: Output of the Face Detection algorithm is given as input to the Face Recognition algorithm. The given input is processed and algorithm checks for a similar face in the database to determine who the person is. The difference between face detection and recognition is that in detection we just determine whether there is a face in the input image or video, but in the face determine whose face it is.

In the proposed system we use Face detection to find whether a human is present in the scene and if a face is detected than the face is cropped along the axis of bounding box and sent as an Email or MMS to the user.

We have used Raspberry PI a credit card shaped micro-controller which functions likes a computer. There are various surveillance systems [3] like camera and "C.C.T.V" but they need a person to monitor the activity through monitors and there is a need to maintain the storage and scaling of the storing unit. The proposed system eliminates the need of storage since we use cloud storage system and scaling is not a problem when it comes to cloud storage system

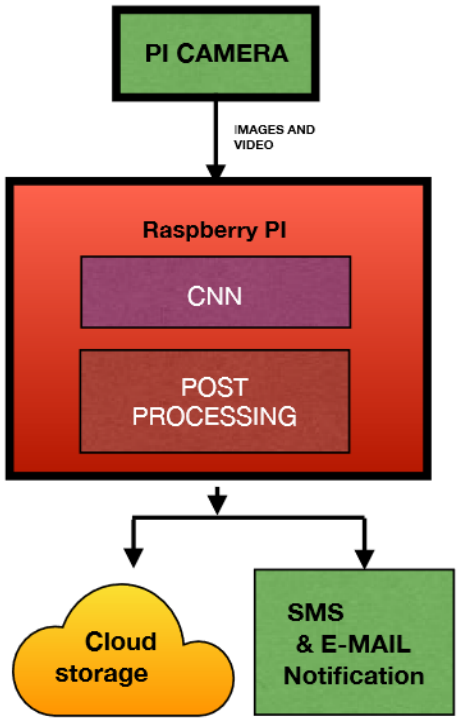

FIg 1. ARCHITECTURE

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* Correspondence Author
Pravin Kumar S Assistant Professor Electronics and Communication Engineering. Saveetha School of Engineering, SIMATS, Poonamalle, Chennai-602105.
Ms. Bhuvaneswari Balachander, Assistant Professor for the department of ECE, Saveetha School of Engineering, SIMATS, Poonamalle, Chennai-602105.

The proposed system architecture is given in "Fig.1". The blocks of this architecture will be explained in the further sections. Python frame work is uses to create the entire software model. "Keras" is a Deep Learning open source module where the Deep Learning functions are open to use .We use "OpenCV" a computer vision python module which in our system is used to import audio and images in to the algorithm. Preprocessing and Pixel manipulation is done using "OpenCV". CNN will detect the faces and passes the faces too Gabor filter for post processing. One the images are post processed, they run through the Database for authorized faces, if the detected face is not authorized then the photo will be sent to the user as a new person entering the premises. Video will be stored in the cloud and linked will be shared through SMS and E-mail.
The brief explanation about the building block of the proposed system will be given in the following sections.

II. PI-CAMERA

Pi camera is a camera module which costs less than 30$ and has full compatibility with Raspberry-PI. Pi camera plugs in directly to the dedicated CSI (Camera Serial Interface) connector of Raspberry-PI. It can deliver a clear image of "5MP" resolution and "1080p" resolution video at 30fps. It is designed and manufactures by the folks in Raspberry-PI so there won't be any compatibility issues since it's completely designed to fit inside Raspberry-PI. The Camera is interfaced to the Raspberry-Pi using 15Pin Ribbon cable. The camera board is very small with a dimensions of "25mm x 20mm x 9mm" so its is hard to identify which gives an advantage in Biometric and security applications. Its weight is around "3"grams which gives an added advantage of portability.

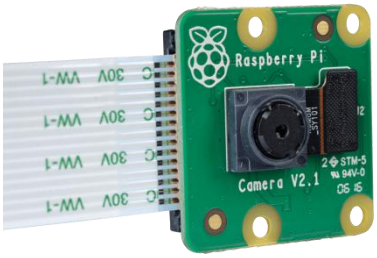

Fig.2 PI camera

III. RASPBERRY PI

Raspberry-Pi runs on an open source OS (Operating System) . Raspbian is the supported OS which is build using Linux. Raspberry-pi is a single board micro-controller. Its General Purpose Input and Output pins can be controlled using Python programming language. Python is ease to use and powerful. Introduction of "Tensorflow Lite" has allowed small embedded systems like Raspberry-pi to run Deep Learning Algorithms like Convolutional Neural Networks. We train the network using cloud GPU (Graphics Processing Unit) service or good computer which has the computational capacity and save the weights file. The saved weights file is provided as an input to the Tensor flow-Lite framework where the functions are optimized and new weights file which is lite weight in terms of file size is obtained. These lite weight weights file is placed inside Raspberry-Pi and processed
"Keras" is a wrapper of Tensorflow which is a light weight Deep Learning library has in-built functions for Deep-learning functions.

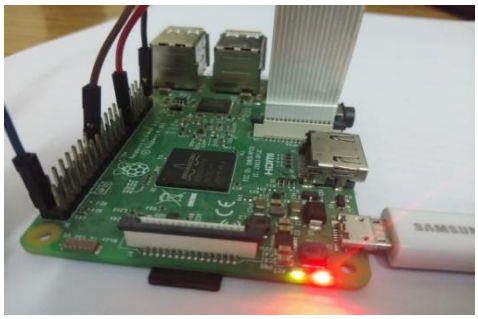

Fig3.Raspberry-PI

IV. CONVOLUTIONAL NEURAL NETWORK

Traditionally face detection tasks where done based on "Histogram of Oriented Gradients" (HOG) and "Linear SVM" [5]. This approach is successful and detects faces but the problem with this model is detection of faces during odd angles. It detects frontal faces; in this case it can detect faces in the front angle but fails to pick up faces when it slightly tilted. Meanwhile, Convolutional Neural Network based faced detection models can pick faces with any odd angles.

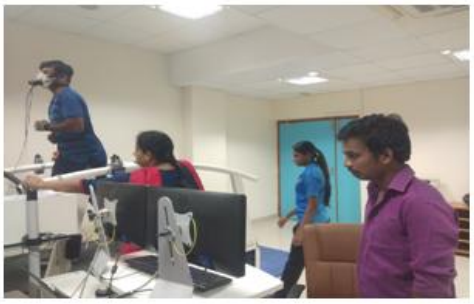

Fig.3 HOG Face detection Output

Fig.4 CNN Face detection Output

"Fig.3" is the output of a HOG face detector, where the four people are in side angle and the faces are not detected, whereas in Fig.4 the side faces are detected with a great precision, [4] it's the output of a CNN face detection algorithm.

The proposed system is a security application and the precision of the face detection should be high. In general public the algorithm should detect faces irrespective of the pose. Accuracy of the face detection increases the accuracy of the whole system.

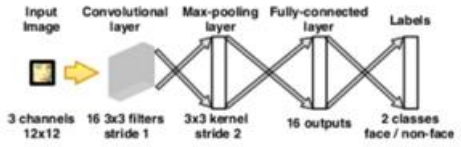

Fig.5 CNN Face detection

The detected faces are represented using a bounding box, which is a red rectangle. These bounding box co-ordinates are shared the post-processing section. We have used 16 3*3 Filters after the input layer, this layer extracts the important features from the input images. [8]CNN tends to scanning features horizontally and vertically on the input images and stride layer helps in skipping steps in which the scanning is done. Fully connected layer takes the pixel values as an array and flatters it. They considered pixels as features to predict the outcome. The final layer is the output layer [7], it's a binary classifier since there are only two conditions is the face is there or not.

V. POST PROCESSING

Face Detection algorithm detects faces and marks them with bounding boxes and the pixels in these bounding boxes are given as an input to other algorithms like face recognition and face clustering. The pixels inside the bounding box is cropped and sent as an input to the post processing stage where a filter is applied to improvise the cropped image. ROI "Region of interest" [6] is pasted in a single image in the "figure 6".

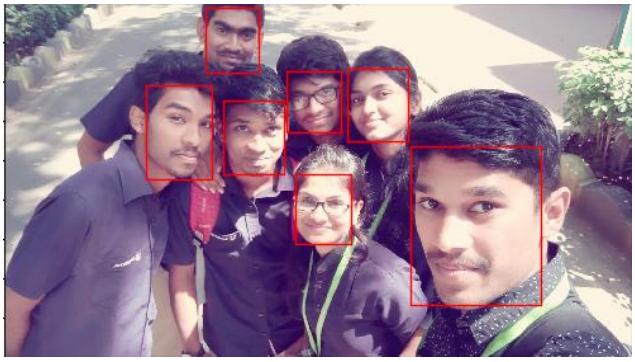

Fig.6 CNN Face detection Input

Fig.7 Post Processing Output

VI. RESULT

The proposed method worked well under crowded situations and fulfilled the application of a security system although there are problems when the person is very far from the camera. Problem of pose is resolved by using CNN in face detection but light and glare problems are still noticed in odd cases. Further research will be conducted to fix the range issue and problems due to light change.

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AUTHORS PROFILE

Pravin Kumar S [1] is a UG scholar under the stream of Electronics and Communication Engineering. Saveetha School of Engineering, SIMATS, Poonamalle, Chennai-602105.

Ms. Bhuvaneswari Balachander [2] is an Assistant Professor for the department of ECE, Saveetha School of Engineering, SIMATS, Poonamalle, Chennai-602105.