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Design and Development of an embedded based Facial Recognition System using UDOO Android

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Abstract : *In recent years face recognition system play an important role in security systems used for wide range of applications like passport/ID card authentication, home security, criminal screening, surveillance, enterprise security and government events security. From the past three decades many algorithms were developed to face recognition. But, implementation and maintenance of this is still remained very challenging in real time applications due to high cost of hardware, software and maintenance. Keeping this in view an attempt has been made in the developed a low cost and portable an embedded system for facial recognition system. For implementation of hardware, UDOO quad board with camera used and for software, android kitkat-v.4.4.2 used. To the best of our knowledge, this is the first time in India that this security system is being developed in the open literature using UDOO. The novelty is used for integration of a facial recognition system for e-passport system which is automatically identifying and verifying a person from a digital image. This system successfully tested and implemented in departmental laboratories.*

Keywords: *Android, UDOO, camera, FRS (Face Recognition System), LBPH (Linear Binary pattern Histogram)*

I. Introduction

Face recognition system (FRS) is one of the most interesting application in image processing and it having application to surveillance, robotics, buildings, ATM machines, airports and border check points[1][2]. It is a computer application for automatically identifying and verification of a person or object from a digital image source. From past several years' security system's developers using this face recognition as major concern. Result of this, now a day this face recognition is occupied almost all security areas. This system used for verification (one-to-one matching) and identification (one-to-many matching) purpose. It is still far away from common people, because of its high cost and its maintenance. To overcome this and make it easy to implement and maintenance, here we designed and developed a portable embedded system for face recognition applications. This system worked based on Local Binary Pattern Histogram (LBPH) algorithm is used for face recognition using openCV and using Haar-like features to make to detect occluded faces and increase the detection rate [3-5]. The system having custom designed hardware, based on UDOO quad board with camera and android operating system with custom developed APP. The aim of this system is to address current needs for face identification and verification of persons with low cost, portable, and easy implementation and maintenance. The block diagram of the present system is shown in the figure-1.

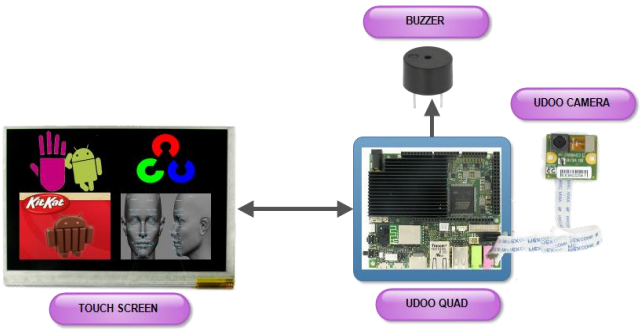

Figure 1: Block Diagram of Face Recognition System using UDOO Android

II. Hardware

A. Udoo Board

Aidilab srl and SECO USA Inc were jointly Launched UDOO development boards in 2013. It is single board computer having quad core ARM cortex-A9 CPU with great performance on both Android and Linux OS and a dedicated ARM processor for the GPIO6. It has Freescale i.MX 6 ARM Cortex-A9 CPU Dual/Quad core 1GHz, 1GB RAM DDR3, 76 fully available GPIO, Arduino-compatible R3 1.0 pinout, HDMI and LVDS + Touch (I2C signals),inbuilt Wi-Fi Module, etc[6]. The UDOO Quad board having very rich hardware setup is shown in figure 2.

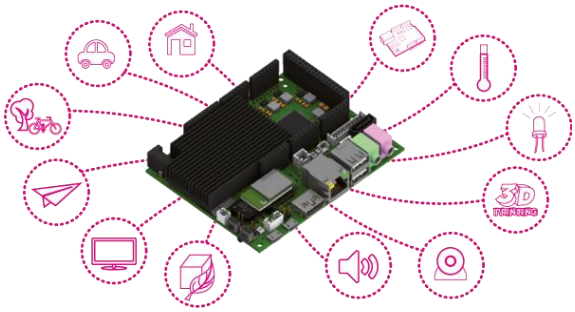

Figure 2: Udoo Quad Board

B. Udoo Camera Module

UDOO camera module consists of OV5640 Image Sensor delivers a complete 5-megapixel camera solution on a single chip that serves the high volume auto focus camera [7]. The main features of this camera module is Auto focus control (AFC) with embedded AF VCM driver, Image transfer rate is VGA (320x480) @120fps, VGA (640x480) @90fps, 720p @60fps, 1280x960 @45fps, 1080p @30fps, QSXGA (2592x1944) @15fps, its having Sensitivity: 600mV/lux-sec, Video capture in Full Field of View (FOV): double sensitivity, improved signal-to. Noise ratio (SNR).The UDOO camera module connected to UDOO Quad board as shown in figure 3[8].

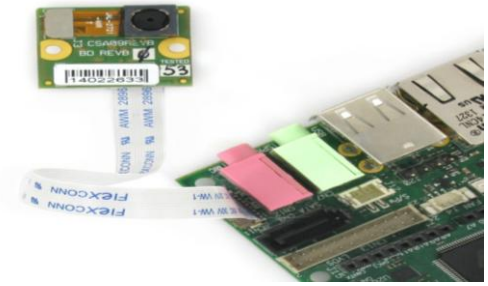

Figure 3: UDOO camera module connected to UDOO Quad board**.**

C. Udoo Lvds 7" Inch Touch Screen

UDOO LVDS having 7 inch touch panel with 7inch RGB display connected through Low Voltage Differential signalling (LVDS) connector. It is a dual touch having resolution of 800x480. It is a Graphical LCD with touch screen provide good GUI and it works on bases of four - wire capacitive technology is the simplest to understand and manufacture [9][10].UDOO 7" inch touch screen connected to UDOO Quad board as shown in figure 4.

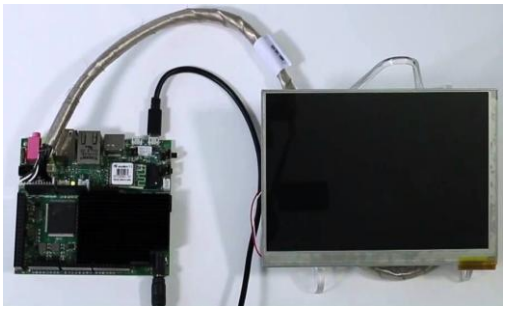

Figure 4: UDOO 7" inch Touch Screen connected to UDOO Quad board.

III. Software

A. Android

An Android is a mobile operating system (OS) based on the Linux kernel and currently developed by Google. It is designed primarily for touch screen mobile devices such as smart phones and tablet computers, with specialized user interfaces for Home entertainments, Automobiles and wrist watches (Android Wear). The OS uses touch inputs that loosely correspond to real-world actions, like swiping, tapping, pinching and reverse pinching to manipulate on-screen objects, and a virtual keyboard. Despite being primarily designed for touch screen input, it also has been used in game consoles, digital cameras, regular PCs and other electronics. It is a powerful Operating System supporting a large number of applications in Smart Phones. These applications make life more comfortable and advanced for the users. Hard ware's that support Android is mainly based on ARM architecture platform.

Android architecture or Android software stack is categorized into five parts:

- Linux kernel
- Native libraries (middleware)
- Android Runtime
- Application Framework
- Application

i. Linux Kernel: It is the heart of android architecture that exists at the root of android architecture. Linux kernel is responsible for device drivers, power management, memory management, device management and resource access.

ii. Native Libraries: On the top of Linux kernel, there are Native libraries such as WebKit, OpenGL, FreeType, SQLite, Media, C runtime library (libc) etc. The Web Kit library is responsible for browser support, SQLite is for database, Free Type for font support, Media for playing and recording audio and video formats.

iii. Android Runtime: In android runtime, there are core libraries and DVM (Dalvik Virtual Machine) which is responsible to run android application. DVM is like JVM but it is optimized for mobile devices. It consumes less memory and provides fast performance.

iv. Android Framework: On the top of Native libraries and android runtime, there is android framework. Android framework includes Android API's such as UI (User Interface), telephony, resources, locations, Content Providers (data) and package managers. It provides a lot of classes and interfaces for android application development.

v. Applications: On the top of android framework, there are applications. All applications such as home, contact, settings, games, browsers are using android framework that uses android runtime and libraries. Android runtime and native libraries are using Linux kernel.

The complete architecture of the Android Software stack is shown in figure 5.

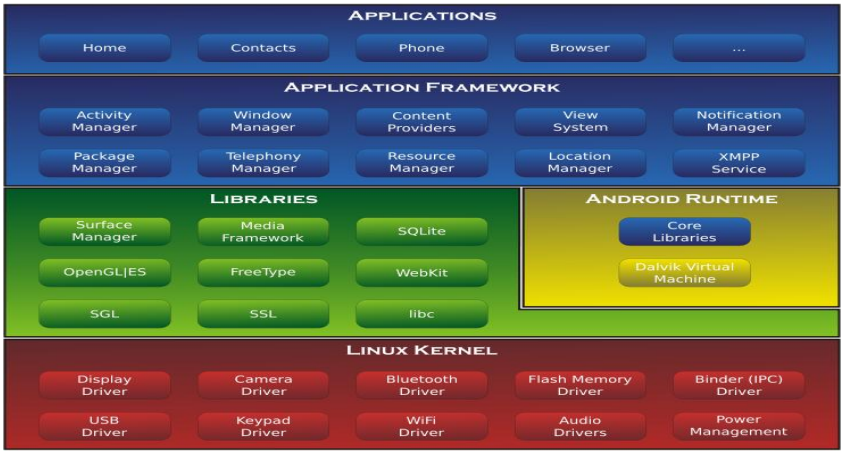

Figure 5: Android software stack.

B. Android Studio: Android Studio is an integrated development environment (IDE) for developing on the Android platform with Android SDK tools. It is freely available and downloaded easily from internet. It is based on JetBrains' IntelliJ IDEA software, the Studio is designed specifically for Android development [11]. It is available for download on Windows, Mac OS X and Linux.

C. OpenCV: OpenCV (Open Source Computer Vision) is a library of programming functions mainly aimed at real-time computer vision, developed by Intel Russia research center in Nizhny Novgorod, and now supported by Willow Garage and Itseez. [12]. It is free for utilization under the open-source BSD permit. Its library is downloaded through internet and easily import using import module menu into the Android Studio.

D. Local Binary Pattern Histogram : Local Binary Pattern Histogram (LBPH) a new rotation invariant and computationally lighter feature sets. It was introduced by the T. Ojala et. el and also they noted its features have performed very well in various applications, including texture classification and segmentation, surface inspection and image retrieval. The original LBP operator labels the pixels of an image (Each bin of histogram (LBP code) can be regarded as a micro-texton) by thresholding the 3-by-3 neighbourhood of each pixel with the centre pixel value and considering the result as a binary number (Figure-6). The operator has been extended to consider different neighbour sizes like LBP4,1 and LBP16,2. For face recognition Ahonen et al. introduced this LBP method. In this method each face image can be considered as a composition of micro-patterns which can be effectively detected by the LBP operator. To find the shape information of faces, here face image can divided into M small non-overlapping regions like R0, R1... RM (as shown in Figure -7).

The LBP bin histograms find out from each sub-region are then concatenated into a single spatially enhanced feature histogram defined as:

$$H_{i,j} = \sum_{x,y} I(f_l(x,y) = i) I((x,y) \in R_j)$$

Where i = 0... L-1, j = 0... M-1.

The very important properties of LBP features are their tolerance against monotonic illumination changes and their computational simplicity [3, 4].

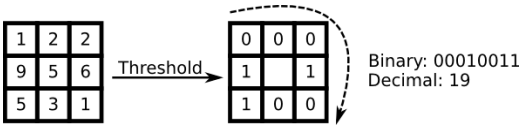

Figure-6 Example of LBP calculation

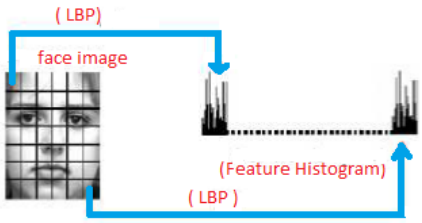

Figure 7 LBP based facial representation

E. Flow Chart: *The complete program flow of execution of the Face Recognition System APP using UDOO android is shown in the Figure 8.*

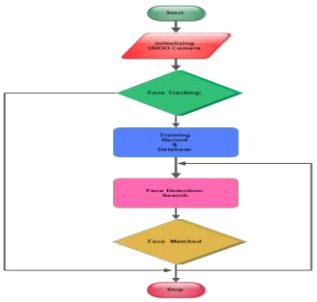

Figure 8: Flow chart of the Face Recognition system using UDOO Android

IV. Result and Conclusion

The FRS is successfully developed using UDOO Android which is shown in figure – 9

Figure -9: Shows complete experimental setup of the FRS

The face recognition is a both challenging as well as important recognition technique. Among all the biometric techniques, FRS approach having one good advantage, which is its user-friendliness.

The proposed FRS has been successfully designed, developed and implemented in our laboratory. The working procedure of the system is mainly classified into Thee steps. Step one is IDEAL state.

Step two is TRAINING state and step three is VERIFICATION OR IDENTIFICATION state.

Ideal state: Generally this mode is an ideal mode which appearance when system OS is powered ON and when the person is sitting infront of the camera this state detects the face and mark the green box on the person's face this is as shown in the figure 10.

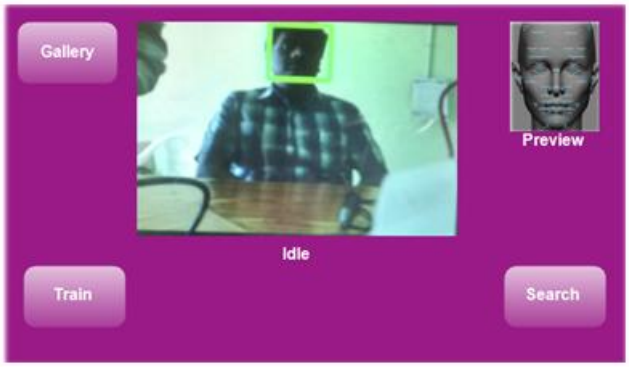

Figure 10: FRS App when in an idle mode

Training/Rec: If the system is in training mode, it captures the unknown person face image using UDOO camera and stores it in database which is placed in available memory card in UDOO board. For new person it registered the details of the particular persons like name and address. If the same person appeared once again it does not stored the details in spite of that it shows "existing user". This procedure continues for N number of persons until stop the training. The training mode of the FRS App is as shown in the figure 11.

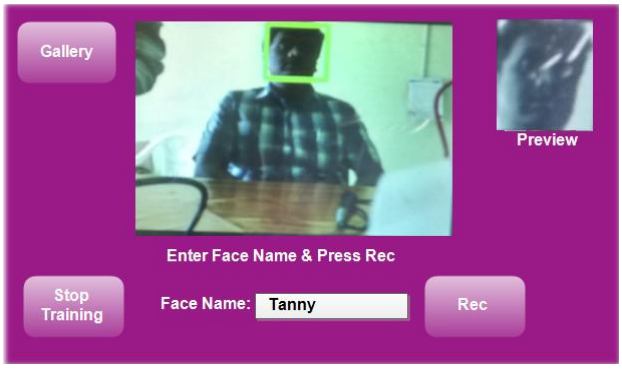

Figure 11: FRS App when in a training mode.

Verification/identification: If the system is in searching mode, it capture the any person face image using UDOO camera and it automatically start comparison with already stored images which are in data base. If the face image matches with stored image, it shows the indication of GREEN colour symbol this is as shown in the figure-12. It means that allow the person or enable the further action like opening of the door in house security system. If the captured face Image does not match with existing images, it shows the indication of RED colour symbol and also it gives the buzzer sound this is as shown in the figure-13. It means that the unknown person entered. Further the system allows the facility to add to the database by the permission of administrator.

Figure 12: FRS App when face is recognized.

Figure 13: FRS App when face is not recognized.

The scope of this system in India is very vast areas like, in order to find the ATM crimes. It is suggested to prepare the database of all ATM users' details. And implement the FRS at all ATMs. So, whenever user will enter in ATM the system automatically captures and compares with database images, it allows the person if it matches. To avoid fake voters in elections. And this system can also use in various examinations. Particularly in our case we implemented this system in e-passport system which is under development stage in our department. The present developed embedded system is very portable, so it can use any ware and any person with minimum cost. And another very important feature in this system is, developed FRS APP can also installed in any android smart phone. Performance of the developed system is quite satisfactory. This paper addresses the feasibility and needs of FRS in individual security systems. It is possible that in the near future, there will be FRS that will incorporate a flexible combination of security features.

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