Facial Expression Recognition using Raspberry Pi

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Abstract— The goal of this article is to provide an easier human-machine interaction routine when user authentication is needed through face detection and recognition. With the aid of a regular web camera, a machine is able to detect and recognize a person's face; a custom login screen with the ability to filter user access based on the users' facial features will be developed. The objectives of this thesis are to provide a set of detection algorithms that can be later packaged in an easily portable framework amongst the different processor architectures we see in machines (computers) today. This project is devoted to build an e-camera which is a facial expression recognition system based on Raspberry Pi from a live Pi Camera feed and get results in real time processing. Although computer vision and facial expression recognition technology have made significant progress in recent years with many professional systems available for real-world applications, it still gains strong interest to implement such a system on a smaller device at a reasonable price such as a single-board computer. The proposed system combines image pre-processing and Convolutional Neural Network (CNN) to build the facial expression recognition model. In pre-processing, the HaarCascade is implemented for face detection. Moreover, 68 facial landmarks are collected for expression feature extraction. Then, CNN is used for training and testing of face expressions classification. The trained CNN model is saved in Raspberry Pi for real-time facial expression recognition. All the computing algorithms are performed on the eCamera. Only the face expression recognition results are delivered to users.

Keywords: Face, Expression, CNN, Raspberry pi

I. INTRODUCTION

A. Face Detection:

Face detection determines if there are any faces in the image and where are they located. This step takes an image as input and produces patches containing all the faces in the image. In order to make face recognition system more robust and easy to design, face alignment is performed to justify the scales and orientations of these patches. Besides serving as the preprocessing for face recognition, face detection could be used for region-of-interest detection, retargeting, video and image classification, etc.

B. Face Recognition:

With the information vector in hand, the next and final step would be to recognize the faces. Face recognition step takes in the feature vectors as input and identifies the faces. To achieve this, a face database is built with multiple images of persons. These images are used to extract features of the person. The features extracted in the last step are compared to each face class in the database and a match is identified. Over the past two decades, face recognition has been studied extensively. Of the many algorithms developed, some of the most common ones are Eigen faces, Fisher faces and local binary patterns histograms.

According to a report from the United Nations, "There is approximately 20 percent of youth experiencing a mental health condition each year on a global level". Young generation is at great risk for a variety of mental-health conditions. Mental health problems affect about 1 in 10 children and young people, including depression, anxiety and conduct disorder, and are often a direct response to what is happening in their lives.

Facial expression is one of the direct reflections during daily life to show their emotions which is a key factor to mental status. Therefore, the design of a real-time facial expression recognition system to look after our young generation is an urgent and vital thing to do. The association of scientific fields in computer vision, machine learning, and the artificial intelligence technologies is more and more important in real life by its numerous human-computer interaction cutting edge applications, such as Face ID on iPhone X and a humanoid robot.

The human-computer interaction is believed to produce a high impact effect when the machine could positively communicate and interact with a human. Computer vision is actually the study of visual data. With a large number of sensors around the world, the amount of visual data has been growing exponentially. So it's critical for us to develop algorithms that can utilize and understand the data. Vision is one of the most important and prioritized senses we human beings have. We can constantly look at the world around us and quickly identify what we see. We can recognize what the expression is on a person's face instantly. However, machines are not capable of this high-level generalization, so we need to train them to mimic the human brain and obtain the ability to understand human performance. With the huge and rapid development of human-computer interaction applications, machines are required to have the ability to read human facial expressions in order to identify and sense human emotion. With the power of high performance computing technology, the combination of deep learning and computer vision has been pushed to a new stage. Machine learning allows perceptrons to learn and represent data with neural-like architecture to understand information. Deep learning is one of machine learning techniques. One of the most significant deep learning schemes used in conjunction with computer vision research is Convolutional Neural Networks(CNN). CNN models have shown tremendous capacity and ability in making a good progress in the field of computer vision along with several other fields like natural language processing and speech recognition.

II. PROPOSED METHOD

In this project, we use CNN to classify facial expressions. The face is the most important object to humans. Facial

expressions are strongly linked to the person's inner emotions. Researchers have used human observation of recorded videos to try to assess emotional response. Although human assessment has many limitations, for example, the same expression may seem differently by different person, facial expression recognition technology offers an opportunity to overcome some of these limitations, delivers a much greater level of insight about personal sentiment and reactions. Facial Action Coding System (FACS) is the most commonly and widely used guide for human facial expression recognition since its publication 40 years ago. Based on an anatomical analysis of facial action through the codification of facial expression in 44 "action units" (AUs), through observational and electromyography study of facial behavior, they determined how the contraction of each facial muscle, both singly and in unison with other muscles, change the appearance of the face. The paper talks about six basic emotions: anger, disgust, fear, happiness, sadness and surprise. This project proposes to deal with these six emotions, and plus the neutral face, total seven categories of expression recognition.

A. System setup:

1) Raspberry Pi

The computational module in this project is Raspberry Pi 3 model B. It is a Linux based platform that uses Python as a programming language. In Linux, software development is quite simple as it is an open source code development environment. The main parts of a Raspberry Pi board include processor, memory, HDMI port, Ethernet port, USB ports and abundant global interfaces. It does not include a built-in hard disk or solid state drive, instead, relying on an SD card for operation system booting, and storage. We have a SanDisk 64GB micro SD card preloaded with the official Raspbian OS. Figure 2.1 displays the external view of Raspberry Pi board.

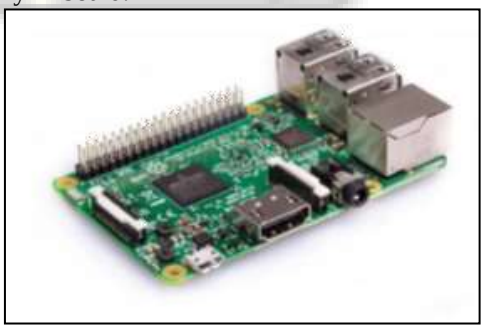

Fig. 2.1: Raspberry Pi 3 Model B+

2) Camera Module:

The Camera Module used in this project is Pi Camera, which is a great accessory for the Raspberry Pi. The Raspberry Pi camera module V2 can be used to take high definition videos, as well as photographs. It utilizes the IMX219PQ image sensor from Sony, which offers high-speed video imaging and high sensitivity. The Raspberry Pi Camera Module offers reduced image contamination such as fixed pattern noise and smearing. It also features automatic control functions such as exposure control, white balance and luminance detection. Figure 3.2 shows that the Pi camera is connected to the Raspberry Pi via a CSI port which allows a USB port free. The CSI bus is capable of extremely high data rates. Figure 4.2 shows that the Pi camera is connected to the Raspberry Pi via a CSI port which allows a USB port free. The CSI bus is capable of extremely high data rates.

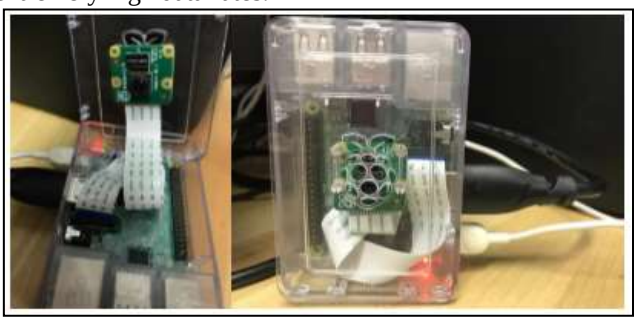

Fig. 2.2: Pi camera connected to Raspberry Pi

During the initial setup, Raspberry Pi was configured as a miniature computer with camera module and an external monitor for viewing the captured images and videos. The Raspberry Pi runs Raspbian OS and the programming language which is Python. We have the step by step setup guide listed below:

1) Step 1. After you get the Raspberry Pi board and Pi camera module, follow the official Raspberry Pi camera installation guide to install it.
2) Step 2. You will need to start up the Pi board and ensure the software is enabled.
3) Step 3. Before the next step, you can run a quick sanity check to ensure that Raspberry Pi camera is working properly. We can use command $ raspistill -o check.jpg to do the checking. This command activates Raspberry Pi camera module, displays a preview of the image, then after a few seconds, snaps a picture, and saves it to the current working directory as check.jpg.
4) Step 4. Install picamera module for python. Notice in command line we should install picamera[array], and not just picamera, the command line using pip to install is: $ pip install "picamera[array]"

3) Python and OpenCV:

Python is an interpreted, high-level and general-purpose programming language. Created by Guido van Rossum and first released in 1991, Python's design philosophy emphasizes code readability with its notable use of significant whitespace. Its language constructs and object-oriented approach aim to help programmers write clear, logical code for small and large-scale projects. Python is dynamically typed and garbage-collected. It supports multiple programming paradigms, including structured (particularly, procedural), object-oriented, and functional programming. Python is often described as a "batteries included" language due to its comprehensive standard library.

4) Keras :

Keras is a Python Deep Learning library, a high-level neural networks API, which is written in Python and is capable of running on top of many frameworks, like TensorFlow, CNTK, and Theano. Through its user friendliness, modularity and extensibility, Keras allows easy and fast prototyping. It is one of the most powerful and easy-to-use Python libraries for developing and evaluating deep learning

models. Moreover, Keras can run seamlessly on CPU and GPU. All these features allow us to use Keras to build and train our CNN. There are two main types of models available in Keras: the Sequential model, and the Model class used with the functional API. Here in our project, we use the Sequential model. The Sequential model is a linear stack of layers. We need to notice that the first layer in a Sequential model needs to receive information about its input shape. In machine learning the shape of input image is a three dimensional tuple, formatted as Height, Width, Channel. There are two ways to shape the input, one is channel first and the other is channel last.

5) TensorFlow:

TensorFlow is a free and open-source software library for dataflow and differentiable programming across a range of tasks. It is a symbolic math library, and is also used for machine learning applications such as neural networks. It is used for both research and production at Google. TensorFlow was developed by the Google Brain team for internal Google use. It was released under the Apache License 2.0 on November 9, 2015.TensorFlow is Google Brain's second-generation system. Version 1.0.0 was released on February 11, 2017. While the reference implementation runs on single devices, TensorFlow can run on multiple CPUs and GPUs with optional CUDA and SYCL extensions for general-purpose computing on graphics processing units. TensorFlow is available on 64-bit Linux, macOS, Windows, and mobile computing platforms including Android and iOS. Its flexible architecture allows for the easy deployment of computation across a variety of platforms (CPUs, GPUs, TPUs), and from desktops to clusters of servers to mobile and edge devices.

B. System Diagram:

Our proposed system follows the main steps similar to ordinary facial expression recognition systems such as face detection, feature extraction, and facial expression classification. However, there are other steps to generate features between neutral and expression frames. The system is composed by following parts: Pi camera to capture an image, and Raspberry Pi board to run image recognition programs. Compatible monitors also connected with this system during initial stages to preview the captured images and show the user. The system diagram is shown in Figure 2.3.

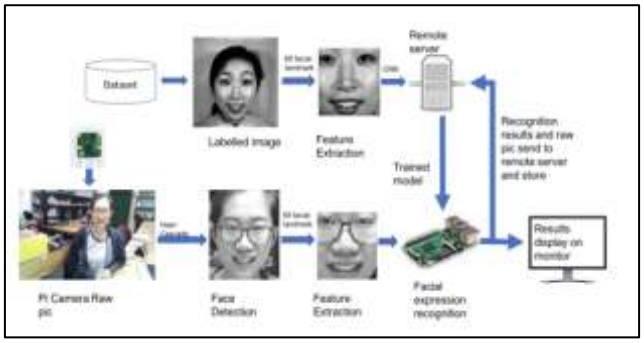

Fig. 2.3: Facial expression recognition system overview.

The whole system contains two parts, model training and raw input image expression classification. In the model training part, we used all frontal face, head centered with blank background images from the datasets. There is no need to waste computation on face detection. The labeled image from dataset will go directly to feature extraction, where we use 68 facial landmarks as prototype to number the common facial specific features we will use to feed to the following CNN architecture. After feature extraction, we have a clean face image with facial parts that will contribute to an expression. This face image then is resized to (64×64). Before starting to train CNN classifier, we further pre-process our input data by scaling the data points from [0, 255] to the range [0, 1], also convert the label to the image to vectors using one-hot encoding(One-hot encoding transforms categorical features to a format that works better with classification and regression algorithms.). We then perform a training/testing split on the data using 75% of the images for training and 25% for testing. Subsequently, we will perform some data augmentation, enabling us to generate "additional" training data by randomly transforming the input images using the parameters, 30 degree range for random rotations, random horizontal or vertical shifts, shear intensity (Shear angle in counter-clockwise direction as radians), small range for random zoom, and randomly flip inputs horizontally. This allows us to use a smaller dataset and still achieve good results. The next step is training the CNN. The trained CNN model will be loaded to Raspberry Pi board.

III. RESULT

Facial Detection and recognition research has been widely studied in recent years. The facial recognition applications plays an important role in many areas such as security, camera surveillance, identity verification in modern electronic devices, criminal investigations, database management systems and smart card applications etc. User's emotion using its facial expressions will be detected. These expressions can be derived from the live feed via system's camera or any pre-existing image available in the memory. Emotions possessed by humans can be recognized and has a vast scope of study in the computer vision industry upon which several researches have already been done. The work has been implemented using raspberry pi. The scanned image (testing dataset) is being compared to training dataset and thus emotion is predicted.

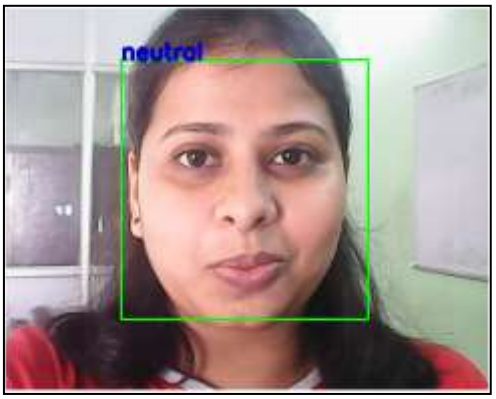

Fig. 3.1: Neutral face detected

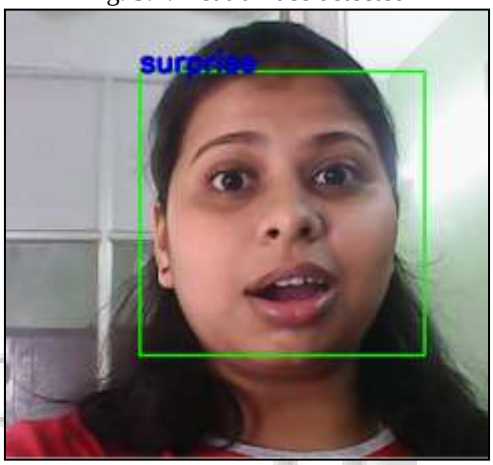

Fig. 3.2: Surprised face detected

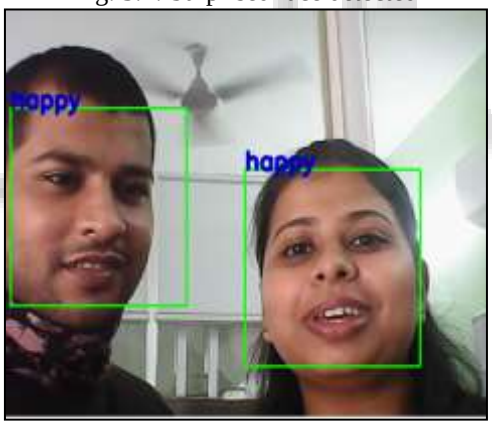

Fig. 3.3: Happy face detected

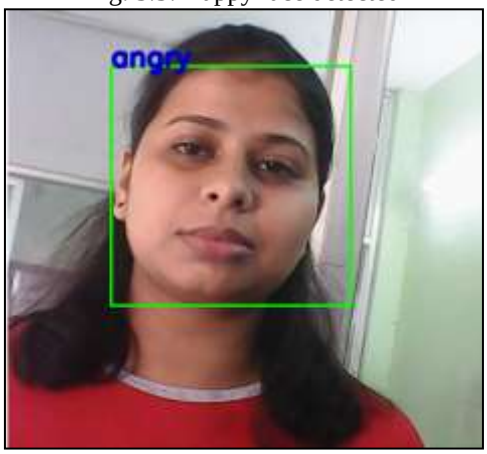

Fig. 3.4: Angry face detected

IV. CONCLUSION

Face recognition applications are used improve access to identify and verify the people by their face features. Hence interpreting the facial features and their actions is much required. As these features and expressions helps in classify the emotions of human face. Recent advances in technology has resulted in the use of Artificial intelligence system as these systems are capable to understand and realize the emotion recognition through facial features. Hence this is an attempt to prove the existence of latest technological developments for human-computer interaction. Artificial Intelligence can be used to solve intriguing tasks such as emotion detection, although this task was quite convolute even more when using a great number of images. Artificial Intelligence can be used to solve intriguing tasks such as emotion detection, although this task was quite convolute even more when using a great number of images. We humans also sometimes make a mistake while recognizing someone's emotion so is our program.

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