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WEB APPLICATION OF FACIAL EMOTION RECOGNITION IN CLASSROOM LEARNING ENVIRONMENT WITH RASPBERRY PI 4

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***Abstract*— This project is focused on developing a web application that integrates facial emotion recognition technology with the Raspberry Pi 4 and its camera. The application allows educators to analyze students' emotional responses during lectures, which can help them evaluate learning comprehension and refine teaching techniques. The Raspberry Pi 4 captures student faces and sends the data to the server application through motion stream. The web application, developed using Flask, displays comprehensive information on student emotions. This information can help educators make informed decisions about their teaching methods. Although it went to various testing, there were some challenges such as setting a maximum number of images during model training due to memory constraints. This project is a promising application for emotion-aware education. It can contribute to improved student-teacher interactions and foster a conducive learning environment. The successful integration of facial expression recognition technology with the Raspberry Pi 4 promotes a more engaging and emphatic learning environment for all students by empowering educators to assess students' emotional responses and modify their teaching strategies accordingly.**

Keywords*— *facial emotion detection, Raspberry Pi, facial recognition, classroom learning, web application

I. INTRODUCTION

A facial recognition system is a piece of technology that can compare a human face from a digital photo or video frame to a database of faces. In recent years, more technology has begun to use facial recognition algorithms on security and user identification. In a face recognition algorithm, the face image detector finds human faces in a typical image against a simple or complicated background, and the face recognizer determines who this person is [1]. Faces contain a wealth of information about a person's identity, as well as their mood and mental condition. Facial expressions are the most expressive means by which people express their feelings. Next to speech, facial expressions are the most reliable source of information for interpreting a person's inner emotions [2]. The process of classifying active and spontaneous facial expressions to determine the underlying emotional states is a necessary step in the process of recognising emotions from facial expressions [3]. The students' emotional states are reflected through distinct behaviours that may be automatically identified. The accurate identification of significant facial landmarks such as the forehead, eyes, nose, mouth, and other facial features is essential for facial recognition systems. These landmarks, often referred to as action units of the face, play a pivotal role in conveying and interpreting various facial expressions, making their precise recognition a critical aspect of the process. Students may learn better or worse depending on their emotional states during the learning process, which can put them in a depressed mood if they are unable to control their states in time to curb their enthusiasm for learning. In order to alter the course progress in a timely manner and guarantee that students fully understand the material being taught, teachers aim to understand students' emotional changes and learning status during the course of classroom instruction [4]. This project is aimed at developing a web application that integrates facial emotion recognition technology with the Raspberry Pi 4 and its camera to allow educators to analyse students' emotional responses during lectures, helping them evaluate learning comprehension and refine teaching techniques.

II. MATERIALS

A. Raspberry Pi

An image taken by the Raspberry Pi Camera serves as the starting point for facial recognition. With its Linux operating system and general-purpose input/output pins, the Raspberry Pi is a very affordable computer that lets users explore the Internet of Things (IoT) and control electronic devices for physical computing. Raspberry Pi 4 Model B has 1.5GHz 64-bit quad-focus ARMv8 CPU and 1 GB Slam as the processor which provides the processing power needed for face-verification computations.

B. Raspberry Pi Camera V2

The Raspberry Pi Camera Board V2 is a high quality 8MP Sony IMX219 image sensor custom designed add-on board specifically for Raspberry Pi. It features a fixed focus lens, capable of 3280 x 2464 pixel static images, and also supports 1080p30, 720p60 and 640x480p60/90 video. It connects to the Raspberry Pi using the dedicated CSI interface specifically for interfacing to cameras. Its tiny size at just 25mm x 23mm x 9mm and weight of just over 3g makes it ideal for mobile applications where size and weight are significant.

III. METHODS

For the purpose of facial emotion recognition, various machine learning methods can be applied. This section will discuss the algorithms and methods being deployed for the project.

A. Flask

Flask is a micro web framework that boasts easy to build web application development and APIs [5]. It provides the essentials for building web applications without imposing too many tools and libraries on the developer. Since it is a lightweight and extensible framework, Flask has been chosen to develop the facial emotion recognition system. In this system, the captured motion stream of students' faces is transferred from the Raspberry Pi camera V2 to the web application to pre-process, crop and resize the image and convert the image to grayscale.

B. OpenCV

The Open Source Computer Vision Library (OpenCV) is a substantial open-source resource designed for tasks involving image processing, machine learning, and computer vision. In contemporary systems, its role in facilitating real-time operations is of paramount importance. OpenCV empowers users to analyse images and videos, enabling them to identify objects, individuals, and even decipher handwriting. To begin facial emotion recognition, the Raspberry Pi Camera Board V2 is attached to Raspberry Pi 4 model B and then it will be used to stream the video of students' faces. The web application trains the Raspberry Pi for facial emotion recognition based on a set of photographs that have already been collected and made available from the FER2013 dataset. This dataset contains more than one million facial images labelled with seven emotions, including the seven basic emotions (happiness, sadness, anger, surprise, disgust, neutral and fear).

C. Convolutional Neural Network

This project uses the Convolutional Neural Network (CNN) algorithm for its facial emotion recognition. CNN is an algorithm that belongs to the deep neural network or deep learning family because of the large network depth and because it performs much better when applied to image data. Each training image is subjected to various resolutions of image processing. Following processing, the output from each image is used as an input to the following layer. This algorithm is readily available as a library for use in OpenCV with the help of Tensorflow and numpy.

D. Python

Python version 3 is used to develop this project and integrate the individual components. A few libraries namely TensorFlow and numpy is used to utilize the machine learning algorithms and produce facial emotion recognition results more rapidly and effectively. Fig. 1 displays the system architecture for this project.

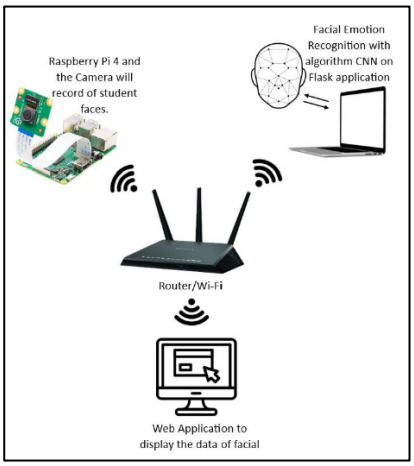

Fig. 1. System Architecture

IV. RESULTS AND FINDINGS

The system's implementation made use of the Flask framework for web interface, OpenCV package and the CCN algorithm technique for facial emotion recognition and image processing in Python. The client, a Raspberry Pi, communicated with the server, a laptop, via the same network. The server is responsible for incorporating facial emotion recognition algorithm and displaying the results based on the lecturer's web account login.

A. Data Collection

A trained model is created during the training process using pre-set parameters and is stored in a file with the extension ".hdf5". This model is utilised as a prediction parameter. The CNN algorithm is used to process the training data to provide feature extraction. The trained data model will subsequently be used as a parameter for comparison with test data in order to forecast facial expressions for the real-time testing method (pictures collected from the camera).

B. Web Interface

In the Flask framework, a well-structured and user-friendly interface is rapidly designed, encompassing different parameters to ensure a seamless user experience. Fig. 2 displays the example web user interface.

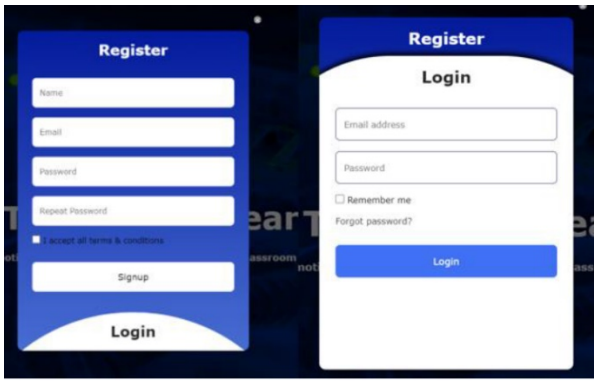

Fig. 2. Web application interface

C. Facial Emotion Recognition

The OpenCV library is utilized to access the motion stream and perform face detection. Detected faces are then resized to 224x224 pixels to match the input size required by the trained model. Emotion predictions are obtained from the model, and the corresponding emotion label is superimposed on the frame. Fig. 3 below shows one example which predicts the emotion "Happy". The system also records the timestamp and associated emotion label to a text file, facilitating emotion tracking over time.

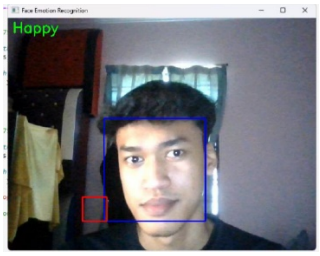

Fig. 3. Emotion prediction of "Happy"

D. Facial Emotion Reporting

The Flask application uses data analysis and visualization techniques after successfully recognizing facial expressions in real-time via the Raspberry Pi 4. Fig. 4 shows the "Emotion Distribution" graph which provides a thorough summary of the frequency of different emotions noticed throughout the recording time. The graph serves as an intuitive representation of emotional patterns, enabling users to grasp the distribution at a glance.

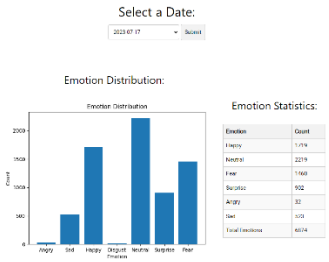

Fig. 4. Emotion distribution

V. CONCLUSIONS

In conclusion, the project's capacity to assist lecturers in evaluating students' emotional responses and using that information to refine their teaching tactics highlights its potential as a strong instrument for educational reform. It acts as a proof of concept and is highly promising for future expansion the field of learning and pedagogy. Admittedly, some challenges may arise due to the limitations in hardware and processing power. The project results remain significant in adding real-time valuable insight into students' emotions during learning.

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