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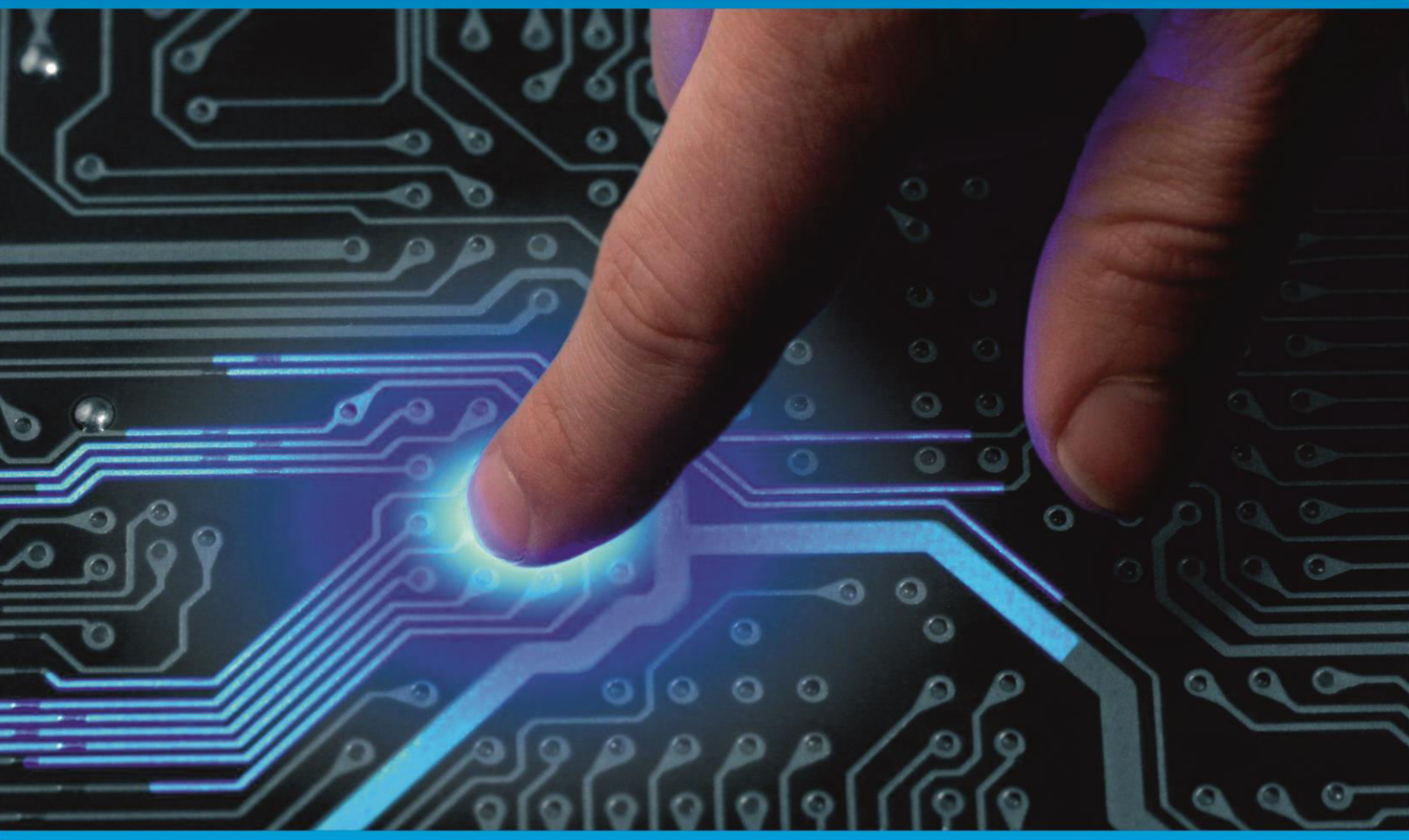

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Patient Monitoring Using Facial Expression Recognition

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ABSTRACT: Facial expression recognition is one of the most important tasks in affective computing, computer vision, human-computer interaction, etc. Facial expressions are a kind of non-verbal communication because it depicts the internal feelings and emotional states of a person. Emotions are a kind of feedback through which a person's current state and need can be identified. The healthcare systems can make use of facial expression recognition, as the doctors and nurses need not constantly monitor patients belonging to certain categories. Using a deep learning approach, a convolutional neural network (CNN) is developed to recognize facial expressions and classify them into basic emotion states such as happy, sad, anger, surprise, disgust and neutral. The model is trained using TensorFlow along with multiple datasets for the face detection and facial expression recognition process.

KEYWORDS: Face Detection, Facial Expression Recognition, Deep Learning, Convolutional Neural Network

I. INTRODUCTION

Deep Learning is a subset of Machine Learning, inspired by the structure of a human brain. Deep learning algorithms attempt to draw similar conclusions as humans would by continually analysing data with a given logical structure. To achieve this, deep learning uses a multi-layered structure of algorithms called neural networks. Neural networks enable us to perform many tasks, such as clustering, classification or regression. With neural networks, we can group or sort unlabelled data according to similarities among the samples in this data. Or in the case of classification, we can train the network on a labelled dataset in order to classify the samples in this dataset into different categories.

The proposed work includes a deep learning approach to help doctors monitor their patients and their response to the medical treatments by keeping track of the facial expression data. This data can be further used for analysis by the doctor. The patient's emotions are constantly monitored throughout the various stages of the treatment and will be recorded for research as well as report generation. This helps in determining the effectiveness of the doctor's approach for treatment. Determining the effectiveness of the approach is dependent on the patient and whether they have a positive or negative reaction to the treatment. The patient monitoring system can help assist doctors and nurses by reducing their workload. It will be of great use during emergencies such as a pandemic where many patients are admitted in the hospital at once. It applies to patients who require close monitoring after having undergone surgery or being given certain medications. For instance, we can identify when the patient has any sudden pain or discomfort. Patients who have met with accidents, those who suffer from mood changes due to mental illness, breathlessness in patients with respiratory problems, etc. are some of the categories of patients who may benefit from this application. This can allow such patients to get immediate medical assistance whenever necessary by sending appropriate alerts to the doctors and nurses. The patient's emotions such as happy, sad, surprised, angry, disgust or neutral will be obtained using facial expression recognition.

The web application consists of a doctor or nurse registration and login for authentication, a dashboard for managing the patient information and the facial expression data. Patient data such as name, id, treatment stage, critical level etc., will be logged into the database. The expression data along with the date and time is stored in a database and can be accessed at any time for future reference. The input video feed can be obtained from the system camera or an external camera. The live video feed of the patient can also be accessed via the dashboard. The face detection and facial expression recognition are performed on the frames obtained from this video feed. It will display a blue box

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detecting the patient's face and the emotion data is displayed along with it. The accuracy of the matched emotion is also shownon a scale of 0 to 1, with 1 being the best match.

II. RELATED WORK

In the recent years, facial expression recognition has been done using various deep learning techniques such as CNN, SVM, random forest,etc. CNN approach is commonly applied in computer vision due to its excellent results in image classification, object detection, face recognition as compared to other methods. For instance, in the year 2020, Karnati Mohan, Ayan Sea, Ondrej Krejcar, Anis Yazidi proposed a system for Facial Expression Recognition using Local Gravitational Force Descriptor based on Deep Convolution Neural Networks. Theproposed DCNN has two branches. The first branch explores geometric features such as edges, curves, and lines whereas holistic featuresare extracted by the second branch. Finally, the score-level fusion technique is adopted to compute the final classification score. The proposed method is compared with existing approaches using four evaluation metrics namely, accuracy, precision, recall, and f1-score. The obtained results demonstrate that the proposed method outperforms all state-of-the-art methods on all the databases. The performance is generally not as good as that in FER under lab-controlled environment, which deserves further study.

In another study in the year, 2020, Kaviya P, Arumugaprakash T…. developed a group facial emotion analysis system using convolutionalneural network. The proposed framework uses the Haar filter to detect and extract face features. Then the convolutional neural network (CNN) is developed to recognize facial expressions. It achieves a final accuracy of 65% for Facial Expression Recognition (FER)-2013 and 60% for custom datasets. Group facial emotions are recognized for both static images and dynamic images acquired in real-time using webcam. The proposed model has used only two datasets for the emotion recognition. This may result in reduced accuracy.

In 2018, Jérôme Thevenot, Miguel Bordallo López, Abdenour Hadid conducted a survey on computer vision for assistive medical diagnosis from faces This survey aims to give an overview of the recent developments in medical diagnostics from facial images based on computer vision methods. Various approaches have been considered to assess facial symptoms and to eventually provide further help to the practitioners. The findings show that with the help of computer vision methods, over 30 medical conditions can be preliminarily diagnosed from the automatic detection of some of their symptoms. In most medical conditions, the final diagnosis of an illness is obtained from the combination of multiple symptoms. These systems still require further validations by clinical trials.

Somchanok Tivatansakul, and Michiko Ohkura, Supadchaya Puangpontip, Tiranee Achalakul published a paper on an emotional healthcare system in 2014. In this paper, emotion detection was done by facial expressions using the Japanese database. It focuses on feature extraction and the classification of emotion detection by facial expressions. To analyse and detect emotions from facial expressions, they improved the DTP approach by applying the one's complement to calculate the representative value of positive and negative binary patterns to construct a 128-level histogram as feature vectors with 256 lengths for emotion classification. This technique can halve the size of the DTP feature vector and improve the accuracy and performance that was confirmed by experimental results using the JAFFE dataset. A remaining issue includes recognition similarity in facial expressions that was caused by confusing different emotions.

III. PROPOSED METHODOLOGY AND DISCUSSION

Facial expression recognition with the help of machine learning and deep learning can be used to monitor patients undergoing medical treatment. The existing patient monitoring systems have IoT based heart rate sensors, temperature sensors and other tracking devices, whereas using facial expression recognition reduces such complexity. Some of the common existing applications of Facial Expression Recognition (FER) are driver drowsiness detection, market research for customer satisfaction, candidate character analysis during interviews, etc. However, there aren't many applications in healthcare. Most of the Facial Expression Recognition models (FER) have been trained using very few datasets. Some of the face detection models like SSD (Single Shot Detection) and YOLO (You Only Look Once) require high computational power. The existing systems do not have the feature of saving the facial expression data and they usually show the results in real time.

This system makes use of facial expression recognition for the patients in hospitals (may not be applicable in certain situations, e.g. Patients who are unconscious or asleep), the collected facial emotion data is then made accessible via an interface for the doctor and nurses. This data will be saved on a database and can be used to analyze and determine the effect each remedy has on the patient. The patient's visitors will also be able to check how the patient

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responds to the treatment and can decide if they want to proceed with the process or not. The TinyFace Detector model is lightweight and can be used in mobile devices too since it uses WebGL kit in the browser. The facial expression recognition model used will have higher accuracy as it has been trained using five datasets. Hospitals have limited number of doctors and nurses. They do not have enough resources during emergencies such as the ongoing pandemic. These patients require utmost attention and their emotions need to be monitored. In order to overcome this, with the help of Computer vision, the patient monitoring can be done using Facial expression recognition in certain situations. It can help doctors determine which medical remedy to follow based on the patients response to the treatments. Moreover, most of the existing Facial Expression Recognition models are not optimized for real time applications.

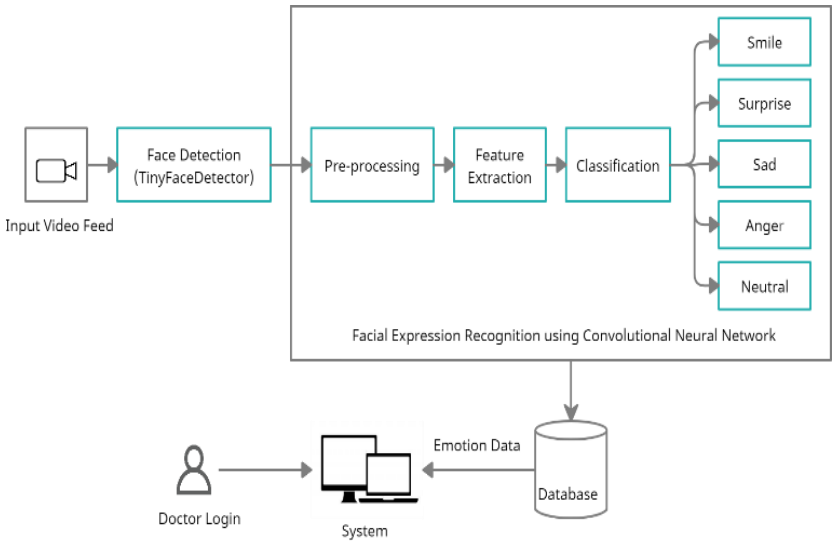

Fig. 1. Architecture Diagram

The overall system architecture, as seen in Fig. 1, is based on receiving the input video stream of the patient being monitored and then performing the face detection on the frames at regular intervals of time. This is then processed by the facial expression recognition model for classification and the emotion data is sent to the client system for analysis.

MODULES

1) Facial Expression Recognition:

The core of the existing system is to detect faces and recognize the emotions using Tensorflow.js, a flexible low-level API for neural networks and numerical computation. The face detection model is trained using public datasets. Real time face detection is done using the Tiny Face Detector which is a simplified version of the Tiny YOLO (You Only Look Once) algorithm. Finally, Facial Expression Recognition (FER) is performed on the detected face using a Deep Convolutional Neural Network (DCNN) and the model is trained using five benchmark databases (FER2013, JAFFE, CK+, KDEF and RAF). The input image for the face detection is obtained from the video feed on a frame by frame basis and at particular intervals of time. This is then passed through the convolutional neural network for classification in facial expression recognition.

2) Server Side API:

The API interacts with MongoDB and the client to store the detected expression data of each patient in the database. This will send the data to the client side system in real time and can be accessed by the doctor at any time. The time stamp is also logged along with the emotion changes and an alert message can also be sent accordingly in case there is any sudden change in mood in patients who are critical. Node JS with Express JS can also be used to create classic web applications on the server-side. With the Node JS event-loop, we can create a powerful web-based dashboard that checks the statuses in an asynchronous manner and pushes data to clients using web sockets.

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3) Client Side Render:

The client side render consists of the interface to provide video input and present the vital information from the facial expression recognition. This forms the frontend of the web application. It will have a login system for the doctors and they can add their patients' data to the dashboard. The corresponding emotion data of the patients being monitored will be obtained from the database and will be available for analysis. The client side user interface is built using React.js. Thus, the web application is scalable and has cross platform support.

ALGORITHMS

Tiny YOLO V2

YOLO ("You Only Look Once") is an effective real-time object recognition algorithm. Object detection refers to finding all the objects in an image and drawing the so-called bounding boxes around them. It is based on regression, where instead of selecting interesting parts of an image, it predicts classes and bounding boxes for the whole image in one run of the algorithm. As of this, the entire process of calculating class probabilities and predicting bounding boxes is executed in one single ANN, which enables optimized end-to-end training of the network, and enables the YOLO network to perform at a high FPS. Tiny YOLO network was developed. and optimized for use on embedded systems and mobile devices. The Tiny YOLO networks are inferior to the full YOLO networks in terms of mAP (Mean Average Precision) but run at significantly higher FPS.

Convolutional Neural Network (CNN)

CNN's, also known as ConvNets, consist of multiple layers and are mainly used for image processing and object detection. CNN' s are widely used to identify satellite images, process medical images, forecast time series, and detect anomalies. CNN's have multiple layers that process and extract features from data:

Convolution Layer : CNN has a convolution layer that has several filters to perform the convolution operation.

Rectified Linear Unit (ReLU) : CNN's have a ReLU layer to perform operations on elements. The output is a rectified feature map. Pooling Layer : The rectified feature map next feeds into a pooling layer. Pooling is a down-sampling operation that reduces the dimensions of the feature map. The pooling layer then converts the resulting two-dimensional arrays from the pooled feature map into a single, long, continuous, linear vector by flattening it.

Fully Connected Layer : A fully connected layer forms when the flattened matrix from the pooling layer is fed as an input, which classifiesand identifies the images.

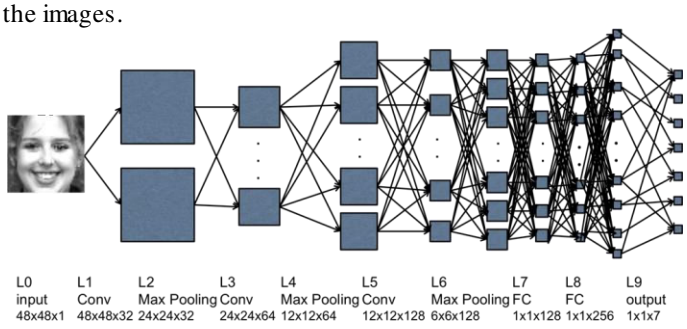

Fig. 2. Layers in Convolutional Neural Network

The input to the emotion recognition model is a gray scale image at 64×64 resolution. The output is 6 emotion classes: neutral, happiness, surprise, sadness, anger and disgust. Fig. 2 shows the layers in the CNN for facial expression recognition.

IV. EXPERIMENTAL RESULTS

The facial expression data are stored in the database after classification. This data is accessed through the interface of the web application.In Fig. 3, we can see the doctor or admin dashboard through which the patient data is managed. It allows the doctor to add patient data, update or delete the existing data, go to the live video feed and finally view the patient report after the recordings have been made.

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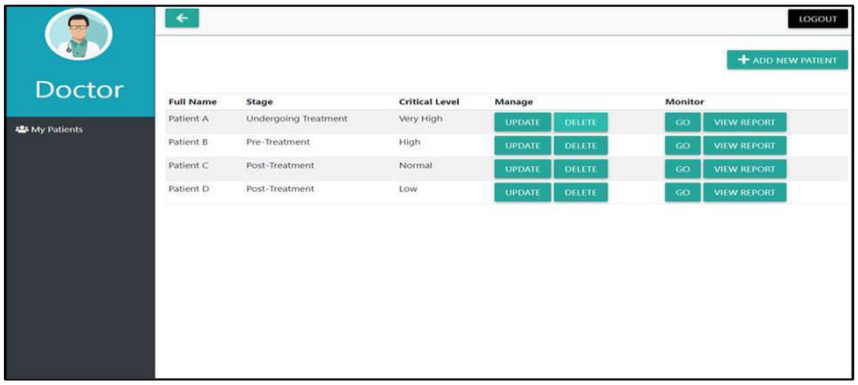

Fig. 3. View Patient Data

The Fig. 4 shows the patient being monitored via a camera. The face detection as well as expression recognition are done and the emotion is displayed along with the accuracy. This data is then stored in the database and accessed through the 'view report' option in the dashboard, as seen in Fig. 5. It shows the retrieved expression data including the date and time of the recordings.

Fig. 4. Monitor Patient

Fig. 5. View Patient Report

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V. CONCLUSION

The detection of a patient's emotional state is done with the help of Facial Expression Recognition (FER) and face detection algorithms. The system can be implemented to assist doctors and nurses in monitoring patients who are critical and require constant attention. This will especially be of use when the hospitals are overcrowded. The doctors can login, add patient data to the dashboard, view and analyze the emotion data of each patient. This can help the staff predict whether the patient is facing any difficulty or change in emotional state.

VI. FUTURE ENHANCEMENT

In the future work, we can improve our approach based on new benchmarks such that the accuracy and efficiency of the Facial Expression Recognition model increases. More use cases for enhanced patient monitoring and identifying health issue specific symptoms through facial expressions, eye tracking, human pose estimation, usage of thermal cameras for detecting thermal radiation, etc. can be combined with this system. The user interface can be improved with the addition of new features such as data visualization using graphs, better response times, etc.

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