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AI-ENHANCED REMOTE PATIENT MONITORING AND EMOTION RECOGNITION SYSTEM USING ANDROID APP

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Abstract: **Patient monitoring systems are evolving into advanced solutions, especially for sensitive environments like ICUs, where real-time insights are critical. These systems leverage artificial intelligence to enhance remote patient care, ensuring continuous observation of patients without requiring constant physical presence. The integration of AI helps healthcare providers monitor patient health parameters and emotional states effectively. This smart healthcare management system tracks vital physiological data, including body temperature and heart rate, ensuring real-time analysis of the patient's condition. It automatically detects normal and abnormal conditions, sending emergency alerts in case of abnormalities. Additionally, it can recognize patients' facial emotions, ensuring that changes in emotional state are promptly communicated to caregivers. The system offers a seamless connection between patients and healthcare providers, even remotely. Through an Android app, doctors and nurses receive notifications about the patient's physiological status and emotional well-being, enabling them to take timely action. This enhanced visibility improves the quality of care, ensuring that caregivers stay informed and responsive, even from a distance.**

Index Terms **– Patient Monitoring,NodeMCU, YOLOv8, Real-Time Detection.**

I. INTRODUCTION

Patient monitoring systems are becoming increasingly advanced, especially in critical care settings like ICUs, where continuous and precise observation is essential to ensure patient safety and well-being, as they operate in highly sensitive environments that demand real time insights and prompt responses from healthcare professionals.

This AI-powered remote monitoring system is specifically designed to enhance the healthcare and overall well-being of patients by continuously tracking vital physiological parameters such as body temperature, heart rate, and other critical health metrics, while detecting normal conditions and immediately sending alert notifications to caregivers whenever any abnormalities or irregularities are identified to enable timely medical intervention.

In addition to monitoring physical health, the system is capable of recognizing the patient's facial emotions, offering valuable insights into their emotional state, which allows caregivers to better understand both physical and mental well-being, particularly for patients with limited communication abilities, ensuring more personalized and empathetic care.

Through an Android app, doctors and nurses receive real-time updates on both physiological data and emotional states, allowing them to monitor patient conditions remotely and stay informed about any emergencies or emotional distress, thereby enabling prompt action and high-quality care even when they are not physically present at the patient's bedside.

A. PROBLEM STATEMENT

The need for continuous, real-time monitoring of patients' health status and emotional well-being is critical, especially for those admitted to intensive care units (ICUs), where conditions can change rapidly, and every second counts. Patients in these settings often require constant observation to detect subtle shifts in their physiological and emotional state, ensuring timely medical intervention to prevent complications. However, conventional patient monitoring systems primarily focus on tracking physiological data such as heart rate, blood pressure, and temperature, leaving out crucial insights into the emotional well-being of patients, which is equally important in delivering holistic care.

Integrating emotional health assessments with physiological monitoring addresses a significant gap in conventional systems by offering real-time access to both types of data. This comprehensive approach allows caregivers to respond promptly to abnormal vital signs and emotional distress, which is particularly important for patients who are unable to communicate their discomfort or needs effectively due to their medical condition. The ability to detect both physical and emotional abnormalities ensures that caregivers can deliver more empathetic and personalized care, improving patient outcomes. This is particularly essential in ICUs, where rapid deterioration can occur, and the patient may be unable to alert caregivers to their needs.

In situations where family members are unable to visit the patient frequently or monitor their condition closely, such integrated systems play a vital role in bridging communication gaps. Since caregivers might not always be physically present near the patient, relying solely on conventional alerts becomes ineffective if doctors or nurses are not immediately available to respond. By utilizing smart patient monitoring systems that deliver real-time alerts and updates through mobile applications, healthcare providers can stay connected with the patient's condition remotely, ensuring swift responses to emergencies and improving the overall quality of care, even from a distance.

II. LITERATURE SURVEY

A. A Deep Learning Approach for Real Time Facial Emotion Recognition

A Deep Learning Approach for Real Time Facial Emotion Recognition" focuses on the significance of facial emotion recognition (FER) as a tool for human interaction and understanding emotions [2]. It explains that there are six primary emotions joyful, sad, disgust, fear, rage, and surprise that can be detected through visual and auditory signals, with two thirds of emotion recognition based on behavioral cues. The paper highlights that facial expressions are one of the most important indicators for emotion prediction, which is why FER has gained significant attention in fields such as psychology, human computer interaction (HCI), artificial intelligence (AI), augmented reality, and automatic driving cars.

Two main approaches to FER: machine learning-based and deep learning-based methods. Machine learning techniques involve a three-step process of extracting a face image, detecting facial landmarks, and using classifiers like support vector machines (SVM)or random forests for recognition. However, deep learning-based approaches, such as convolutional neural networks (CNN), eliminate the need for manual feature extraction, enabling end-to-end learning with more accurate results. Deep learning methods, especially CNN, are highlighted as state of the art tools for facial emotion recognition. These methods rely on creating feature maps from input images, which are then processed through fully connected layers and classified using algorithms like softmax [12].

The introduction points out that while static FER focuses on peak features in static images, dynamic FER analyzes features across multiple video frames to better capture emotions in real-time emotions in real time video feeds. The paper will explore existing literature on CNN models for FER, followed by the proposed methodology, results, and conclusions based on a comparison of the proposed model's performance with existing approaches. In essence, the introduction sets the stage by emphasizing the importance of accurate emotion recognition in interactive technologies and the potential for CNN-based models to surpass traditional methods in performance, especially in real-time applications.

B. Real Time Patient Activity Monitoring and Alert System

In healthcare monitoring, it is essential to track a patient's response to medications and observe the effects on their body. Traditionally, patient monitoring is done manually by nurses, which may lead to human errors and increased workload, making the process costly and less efficient.

To overcome these challenges, an automatic real-time patient monitoring and alert system is proposed. This system enables continuous monitoring using a camera for non-contact observation and body sensors to collect vital health data like temperature, pulse rate, and emotional state. The collected data is processed in real-time and sent to healthcare providers through an alert system using GSM technology in case of any abnormal conditions. This automated monitoring reduces human errors, minimizes staff workload, and ensures better healthcare services, especially in ICU environments.

C. SIPMS : IoT based Smart ICU Patient Monitoring System

In recent years, the rapid advancements in the Internet of Things (IoT) have revolutionized healthcare, particularly in critical environments like Intensive Care Units (ICUs). Patient monitoring systems play a crucial role in managing critically ill patients by ensuring real-time monitoring and instant data availability to medical professionals. With the integration of digital technologies and IoT, healthcare providers can improve treatment quality by continuously tracking vital signs such as heart rate, blood pressure, and respiratory rate. The proposed Smart ICU Patient Monitoring System (SIPMS) leverages IoT to collect patient data, transmit it to the cloud, and provide remote access for healthcare providers. This system minimizes human error and ensures faster response in emergency situations by triggering alerts when abnormal patterns are detected. Incorporating artificial intelligence (AI) frameworks further enhances the system's efficiency by providing predictive insights, making it easier for caregivers to respond proactively to medical situations. Furthermore, the system supports the use of various sensors to monitor parameters like oxygen saturation and ECG signals, ensuring comprehensive patient care. The combination of IoT, AI, and embedded technologies enables effective real-time moni toring, facilitating remote consultations and reducing the burden on hospital staff. As healthcare evolves, the SIPMS model aims to bridge the gap between patients and medical professionals, ensuring immediate intervention and better patient outcomes.

III. METHODOLOGY

This study proposes an AI-enhanced remote patient monitoring and emotion recognition system. The system is designed to provide real-time insights into patients' physiological and emotional states, particularly for critical care environments like Intensive Care Units (ICUs). The methodology involves integrating IoT-based sensors, artificial intelligence algorithms, and an Android application for seamless remote monitoring.

Firstly, the hardware setup includes sensors like MAX30102 for body temperature, heart rate, and oxygen saturation monitoring. These sensors are interfaced with a NodeMCU microcontroller, which transmits real-time data to a Firebase cloud server via Wi-Fi. This ensures remote accessibility of physiological parameters. Additionally, facial expressions are captured through a camera module, and a Convolutional Neural Network (CNN) processes these images for emotion recognition. The CNN model, trained on publicly available datasets, classifies emotions into predefined categories to assess patients' mental states effectively.

The processed data is displayed on an Android app, enabling caregivers and healthcare professionals to monitor patients remotely. The system generates alerts for abnormal vital signs or concerning emotional changes, ensuring timely intervention. This integrated approach not only enhances patient care but also reduces the burden on hospital staff by providing a comprehensive, real-time monitoring solution.

The methodology involves integrating IoT-enabled sensors, a facial recognition module, and an Android application for real-time patient monitoring. Sensors like MAX30102 capture vital parameters such as heart rate, oxygen saturation, and body temperature, while a CNN-based emotion recognition model analyzes facial expressions to assess emotional states. Data is transmitted via NodeMCU to a Firebase cloud server, ensuring secure storage and remote access. An Android app provides caregivers with real-time updates and alerts, enabling prompt responses to abnormalities and improving patient care efficiency.

IV. PROPOSED SYSTEM

In our proposed system,AI enhanced remote patient monitoring emotion recognition system is designed to improve the healthcare of patients. The system continuously tracks vital signs like temperature, heart rate,and oxygen levels. An Android app will enable remote monitoring through updating patient 's condition to doctors and caretakers,even they're not present near.The system also recognizes facial emotions, frequently assessing the patient's emotional state to better understand their current condition. Remote monitoring enables doctors and caretakers to track patients'physiological conditions and emotional states in real time,even from adistance. The proposed system design integrates IoT-based patient monitoring with AI-powered emotion recognition, ensuring comprehensive real-time insights into a patient's physiological and emotional health. The system comprises several modules that work cohesively to achieve this functionality:

A. User Interface and Dataset Collection

In this project, the User Interface (UI) is designed in an Android application to provide real-time monitoring of the patient's health status and emotional state. The UI is user-friendly and provides clear information about the patient's pulse rate, temperature, and detected emotion. For emotion detection, a dataset containing different facial expressions such as happy, sad, angry, and neutral was collected and used to train the emotion recognition model. The dataset was created by capturing multiple images from various individuals in different emotional states to improve the accuracy of detection.

B. .Image Processing and Detection Module

In this project, the Image Processing and Detection Module plays a vital role in recognizing and analyzing the emotional state of the patient. This module captures real-time facial images of the patient using a camera and processes them using image processing techniques. Advanced algorithms are applied to detect facial expressions and classify emotions such as happy, sad, angry, or neutral. The extracted emotion data is then sent to the caretaker via the connected application, enabling remote monitoring of the patient's emotional well-being.

C. Control System

In this project, the control system plays a vital role in monitoring and managing the patient's health parameters. It collects data such as temperature, pulse rate, and emotional status from various sensors connected to the NodeMCU module. This data is then processed and transmitted to the caretaker's Android application through IoT technology. The control system ensures real-time monitoring, enabling quick response and better patient care.

D. Data Acquisition and Processing

In this project, data acquisition is carried out using various sensors integrated with the NodeMCU module. The system collects vital parameters such as body temperature and pulse rate from the patient. Additionally, a camera module is used to capture real-time images to detect the patient's emotional state. The collected raw data is processed using embedded programming, where filtering and necessary conversions are applied to make the data meaningful. The processed data is then transmitted to the Android application via IoT for monitoring by the caretaker in real-time

V. PROPOSED SYSTEM DESIGN

The proposed system is designed to provide an effective and efficient solution for real-time patient monitoring in healthcare environments. This system aims to overcome the drawbacks of manual monitoring by automating the process using IoT and AI

technologies. The system continuously monitors the patient's vital health parameters such as pulse rate and body temperature using sensors connected to a NodeMCU module. Along with physical health, the emotional state of the patient is detected using a camera module and AI-based emotion detection techniques.

All the collected data from the sensors and camera is processed and transmitted in real-time to a dedicated Android application used by the caretaker or doctor. In case of any abnormal health conditions or emergencies, the system generates instant alert notifications to ensure quick action can be taken. This design not only reduces the chances of human error but also provides continuous and remote monitoring of the patient, making healthcare services more reliable and responsive.

A.Training Phase

• Dataset : Images and labels containing different human facial expressions are prepared.
• Augmentation : Various data augmentation techniques like rotation, flipping, brightness adjustment, and scaling are applied to increase the dataset size and improve the model's performance.
• Data Splitting : The dataset is divided into training and testing sets.
• YOLOv8 Architecture:

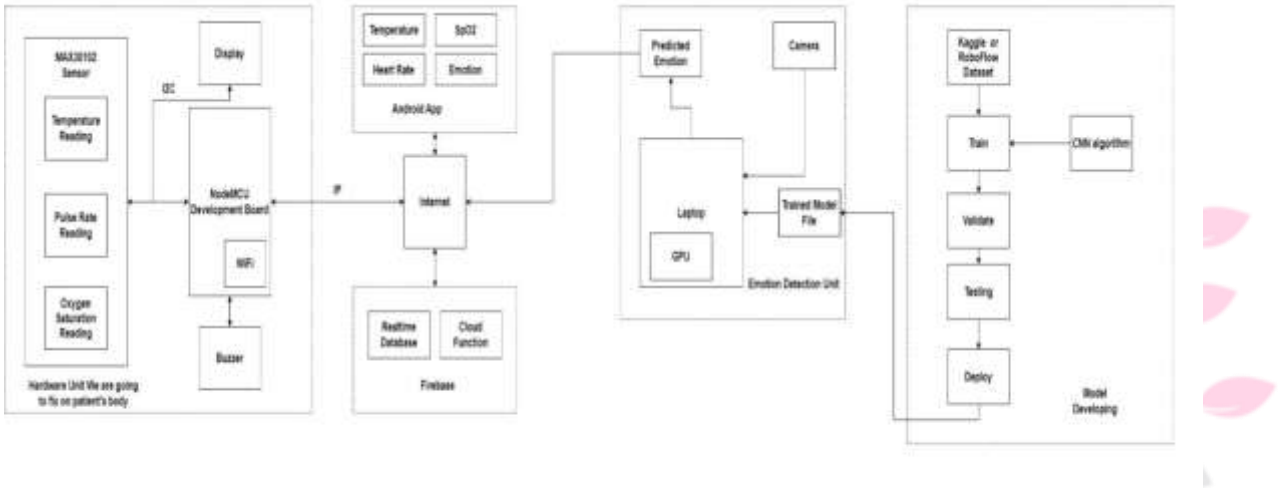

Figure 1. Architecture Diagram

B. Testing Phase

• Hardware Testing: The sensors (pulse sensor, temperature sensor, and camera module) were tested individually to ensure accurate data collection. NodeMCU was tested to check if it was properly connecting to Wi-Fi and sending data to the cloud platform.
• Software Testing : The Android application was tested to verify correct display of patient data. The app was tested for notification alerts sent to the caretaker in case of abnormal readings. Emotion detection algorithm was tested to ensure correct identification of the patient's emotional state through camera images.
• YOLOv8 Model: The trained YOLOv8 model identifies the facial emotion of patient.
• Feature Database: The model's output is stored or referred to for further decision making.

VI. RESULT

The proposed real-time patient monitoring and alert system has been successfully designed and implemented to overcome the drawbacks of the traditional manual patient monitoring system. The developed system continuously monitors the patient's vital health parameters such as body temperature, pulse rate, and emotional condition using various sensors and a camera module. The NodeMCU-based IoT platform plays a vital role in collecting the data from these sensors and transmitting it wirelessly to the caretaker or doctor through an Android application. This ensures that the health condition of the patient can be monitored remotely in real-time without any manual intervention.

Additionally, the system is capable of detecting the patient's emotional state by analyzing facial expressions captured by the camera module. This unique feature helps in understanding the mental status of the patient along with physical health, providing a more comprehensive monitoring solution. Whenever the system detects abnormal values in the patient's temperature, pulse rate, or an unusual emotional condition, it instantly sends an alert notification to the caretaker's mobile application using a GSM module.

This timely notification allows the medical staff or caretaker to take immediate action, ensuring patient safety and better healthcare management. The system is cost-effective, user-friendly, and capable of reducing human errors which are commonly found in manual monitoring methods. Thus, the implemented system has proven to be an efficient solution for real-time patient monitoring, especially in ICU conditions, offering enhanced healthcare services and promoting quick response during emergency situations.

Figure: App Login page

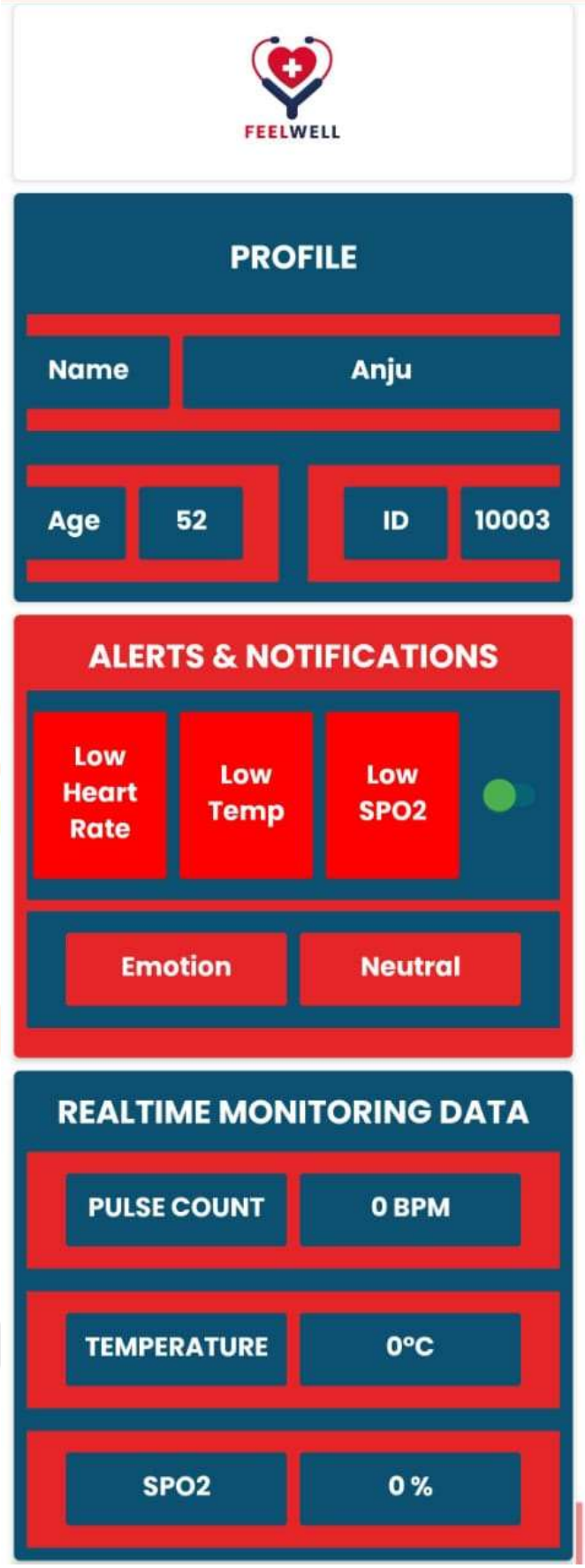

Figure : App Home Page.

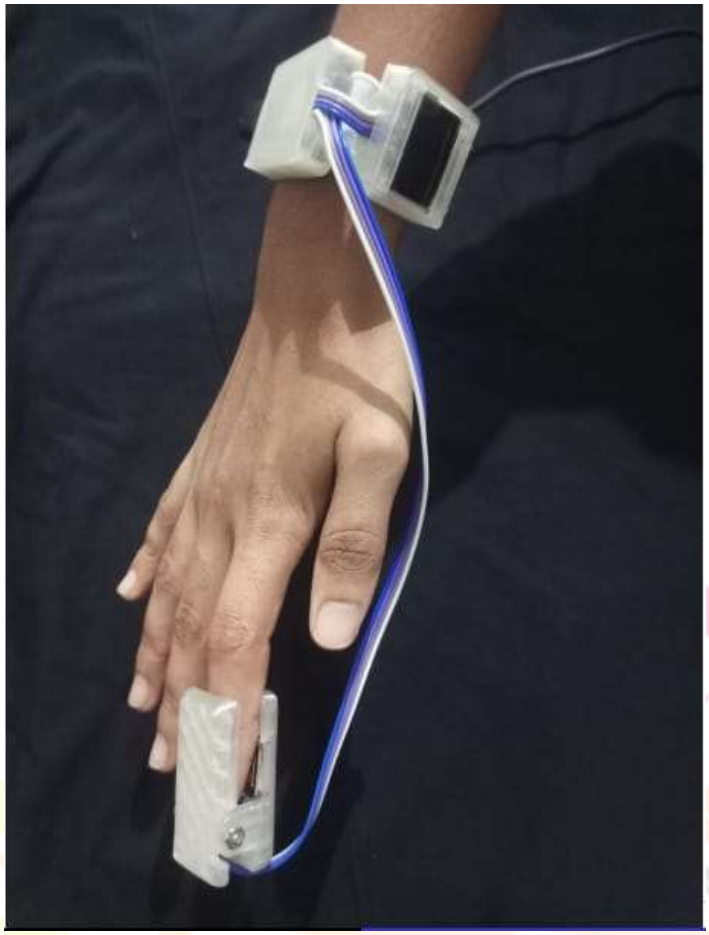

Figure: Device

Figure :Normalized confusion matrix

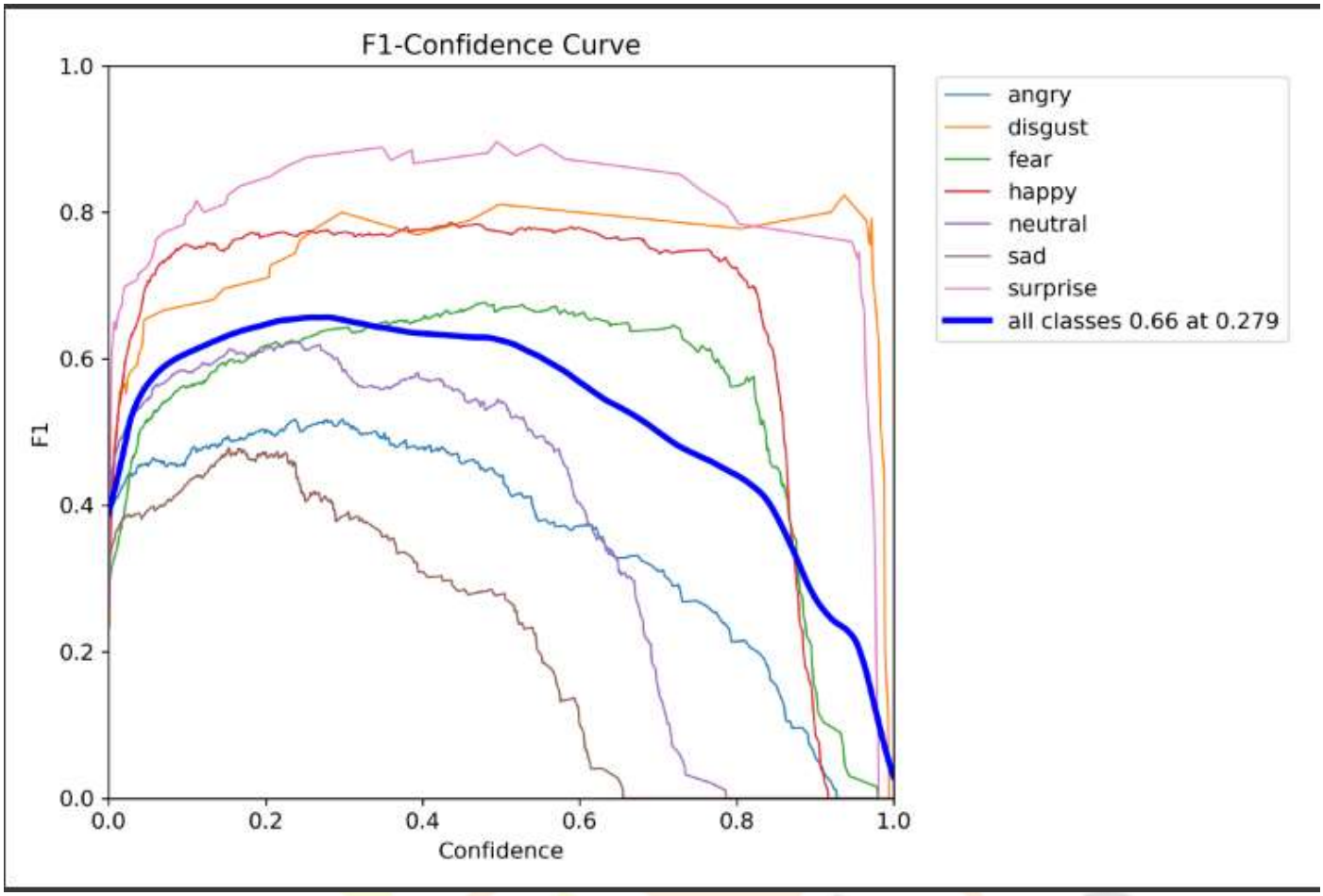

Figure :F1 curve

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