KLE TECHNOLOGICAL UNIVERSITY

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A Senior Design Project Report on

Real Time Facial Emotion Recognition

Submitted in partial fulfillment of the requirements for the award of the degree of

Bachelor of Engineering

in

Electronics and Communication Engineering

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Semester VII

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2024-2025

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CERTIFICATE

This is to certify that the Senior Design Project (SDP) (Code: 20EECW401) work entitled **"Real-Time Facial Emotion Recognition"** is a bonafide work carried out by the student team of **Prajwal Kamble (02FE21BEC061), Prajwal Halgi (02FE21BEC059), Pooja Nandgaon (02FE21BEC058), Rakshita Shivapooji (02FE21BEC068)**. The project report has been approved as it satisfies the requirements with respect to the mini project work prescribed by the university curriculum for **B.E. (VII Semester)** in the **Department of Electronics and Communication Engineering** of **KLE Technological University, Dr. M S Sheshgiri Campus, Belagavi**, for the academic year **2024-2025**.

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DECLARATION

We hereby declare that the Senior Design Project (SDP) presented in this report, entitled "**Real-Time Facial Emotion Recognition**", submitted to KLE Technological University for the completion of the Senior Design Project (Code: 20EECW401) in the 7th Semester, is the original work carried out by us in the Department of Electronics and Communication Engi- neering, KLE Technological University, Dr. M S Sheshgiri Campus, Belagavi, under the guidance of Guide Name, Designation of Staff, Department of Electronics and Communication Engineering.

We further declare that, to the best of our knowledge and belief, the work reported herein has not been submitted as part of any other project or for the award of any course, degree, or diploma at this or any other university or institution. The results presented in this report are solely the outcome of our efforts.

We also confirm that all the work documented in this report has been completed by us.

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ABSTRACT

In recent years, real-time facial emotion recognition has emerged as a significant area of research in human-computer interaction, security, and healthcare. This project aims to develop a system that accurately detects and classifies human emotions from facial expressions in real-time using machine learning techniques, specifically Convolutional Neural Networks (CNN) for emotion classification and You Only Look Once (YOLO) for fast and accurate face detection. By leveraging CNNs' ability to recognize patterns in facial features and YOLO's high-speed object detection, the system can detect emotions such as happiness, sadness, anger, surprise, and neutrality. This solution holds promise for applications in interactive AI systems, mental health monitoring, and enhanced security protocols. The results demonstrate an effective approach to emotion recognition, integrating state-of-the-art deep learning techniques to achieve high accuracy and real-time performance.

Acknowledgements

We would like to express our sincere gratitude to our guide, Prof. Neelam Sommanavar, for her guidance and support throughout the development of this project. Her expertise in machine learning and computer vision was invaluable in helping us understand the intricacies of real-time emotion recognition and its applications. We are grateful for his patience and insightful feedback, which propelled us to explore innovative approaches to problem-solving in facial emotion recognition. We would also like to thank the Department of Electronics and Communication Engineering for providing the resources necessary to conduct this research.

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Chapter 1

Introduction

With the rise of artificial intelligence, emotion recognition through facial expressions has gained significant attention. Emotions play a vital role in human communication, often providing insights into people's thoughts and intentions. In a world where human-computer interaction is increasingly prominent, enabling machines to understand and respond to human emotions can greatly enhance user experiences across various fields, including healthcare, customer service, and security.

This project focuses on developing a system for real-time facial emotion recognition using two prominent machine learning models: Convolutional Neural Networks (CNN) and You Only Look Once (YOLO). CNNs are well-suited for identifying complex patterns in facial features, while YOLO, a state-of-the-art object detection algorithm, enables the system to locate faces quickly and accurately, making it suitable for real-time applications. By combining CNNs for emotion classification and YOLO for facial detection, this system can recognize emotions in live video feeds, offering applications in fields where understanding emotions is crucial.

1.1 Motivation

1. Human-Computer Interaction Enhancement: Emotion recognition can significantly improve user experience by enabling more intuitive and responsive computer interactions. Real-time analysis allows systems to adjust responses based on detected emotions, creating a personalized experience for users.
2. Mental Health Applications: Emotion recognition holds promise in mental health monitoring, where automated systems could provide insights into a person's emotional state over time, assisting healthcare professionals in early detection and ongoing evaluation.
3. Real-time facial emotion recognition can be beneficial in surveillance and security, where identifying unusual emotional patterns may help detect threats or suspicious behavior in high-security areas.
4. Advances in Deep Learning: CNN and YOLO represent breakthroughs in machine learning, allowing high accuracy in image processing and object detection. This project leverages these advancements to push the boundaries of what is possible in real-time applications

1.2 Objectives

- Develop a Real-Time Emotion Recognition System: Build a system capable of detecting and classifying emotions in real-time video feeds by utilizing CNN for emotion classification and YOLO for face detection.
- Implement Accurate Face Detection and Emotion Classification: Use YOLO to locate faces quickly and accurately in video frames and CNN to classify detected emotions with high accuracy.
- Design an Efficient User Interface: Create a user-friendly interface to display real-time emotion recognition results, ensuring accessibility for potential end-users.
- Evaluate System Performance: Assess the system's accuracy, latency, and overall performance, ensuring it meets the demands of real-time applications.

1.3 Literature Survey

1. Convolutional Neural Networks (CNN) in Emotion Recognition: CNNs are widely used in image classification tasks due to their ability to automatically detect and learn spatial hierarchies in images. Studies such as [1] highlight CNN's application in emotion detection from facial expressions, demonstrating high accuracy when trained on large emotion datasets. For example, CNN- based models trained on datasets like FER2013 and CK+ have shown reliable performance in distinguishing between basic emotions like happiness, sadness, and anger.
2. YOLO for Real-Time Object Detection: YOLO has emerged as one of the leading algorithms in real-time object detection due to its efficiency and speed, as discussed in [2]. By processing images as a single neural network, YOLO achieves superior performance, making it highly suitable for applications re- quiring real-time facial detection in live video feeds.
3. Combination of CNN and YOLO for Face Detection and Classification: Integrating CNN with YOLO has been explored in recent research as a robust approach to emotion recognition. YOLO's rapid face detection paired with CNN's accuracy in emotion classification provides an optimal solution for real- time systems, as shown in studies [3]. Such hybrid approaches have proven effective in handling the trade-off between accuracy and processing speed in emotion recognition systems.

1.4 Problem statement

Develop a Real-Time Emotion Recognition System: Build a system capable of detecting and classifying emotions in real-time video feeds by utilizing CNN for emotion classification and YOLO for face detection.

1.5 Applications in Societal Context

(a) Education: In classrooms, emotion recognition helps teachers understand student engagement, detect frustration or boredom, and adjust teaching methods accordingly.

(b) Customer Service: Enhances user experience in customer service sectors (e.g., call centers or face-to-face customer interactions) by analyzing the emotional state of customers for improved service.

(c) Retail: Helps businesses understand customer satisfaction through facial expressions, optimizing marketing strategies and product offerings.

(d) Security Law Enforcement: Real-time emotion analysis can aid in detecting suspicious or unusual behavior by analyzing body language and facial expressions in public areas.

(e) Automotive Industry: Emotion recognition systems in cars for detecting driver fatigue or frustration, improving road safety.

1.4 Project Planning and Bill of materials

1.4.1 Project Overview:

- **T**he project focuses on creating a system that can detect and recognize human emotions from real-time facial images using machine learning techniques. By employing Convolutional Neural Networks (CNN) and You Only Look Once (YOLO) algorithms, the project aims to build an efficient and accurate real-time emotion recognition system. YOLO is used for face detection, while CNN is employed for emotion classification.

1.4.2 Project Scope:

- **E**motion Classification: The system should classify emotions like happiness, sadness, anger, surprise, fear, and disgust.
- **F**ace Detection: Using YOLO for high-speed, high-accuracy face detection in real- time.
- **R**eal-Time Processing: The system will operate in real-time, processing video streams from cameras.
- **A**ccuracy: Aiming for high accuracy and robustness across various lighting conditions and facial angles.

1.4.3 Project Timeline:

- **Key Milestones:**
  Data Collection
  Preprocessing
  Model Development
  Testing and Evaluation
  Deployment
- **Visual Representation:** Gantt chart illustrating the timeline for each phase.

1.4.4 Resources Needed:

Components:

- YOLO (You Only Look Once): For real-time face detection.
- CNN (Convolutional Neural Network): For emotion classification.
- Webcam/Camera: For capturing real-time video feed.
- Python and Libraries: OpenCV, TensorFlow, Keras for implementing face detection and emotion classification.
- Real-Time Processing Hardware: A computer or edge device for processing the data

1.5 Organization of the report

1.5.1 System Design

The system design for real-time facial emotion detection focuses on detecting emotions from facial expressions in live video feeds. The system integrates YOLO for face detection and CNN for emotion classification. It processes each frame to detect faces and classify emotions accurately. The system requires a real-time processing unit and a camera for continuous video input, with Python-based tools such as OpenCV and TensorFlow to handle the detection and classification tasks. The architecture ensures real-time data processing and provides an effective solution for emotion recognition.

1.5.2 Implementation details

The real-time facial emotion detection system is implemented using YOLO for face detection and a pre-trained CNN model for emotion classification. The system continuously processes video frames from a camera, detects faces using YOLO, and classifies the emotions using CNN. The emotion classification results are displayed in real-time on a user interface, which can be a simple desktop application or web interface, depending on the deployment. Python is used as the programming language, with libraries like OpenCV for video capture and TensorFlow/Keras for model execute.

Chapter 2

System design

In this Chapter, we list out the interfaces.

1.1 Functional block diagram

The block diagram represents the real-time emotion detection system, showing the components involved: Camera for video capture, YOLO for face detection, CNN for emotion classification, and the user interface for real-time result visualization

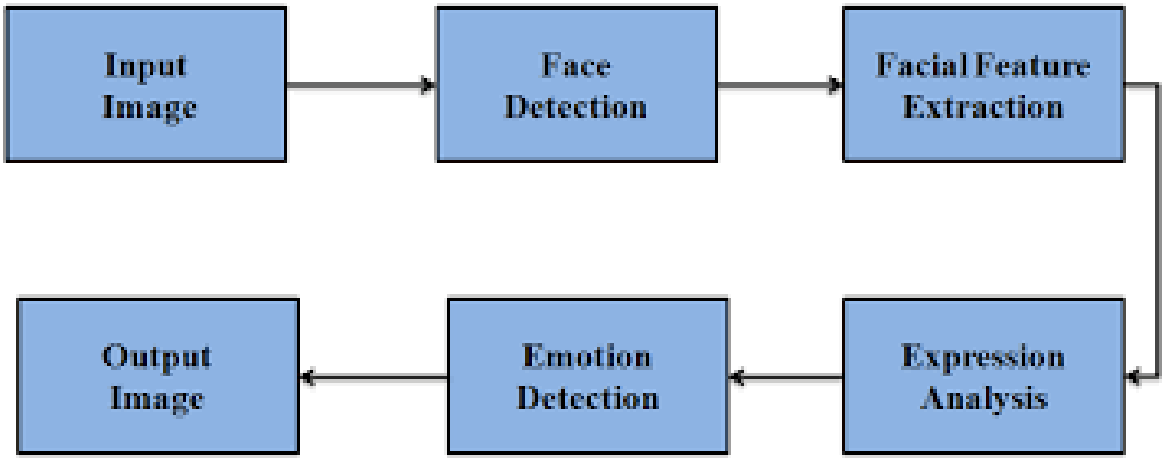


Figure 2.1: Functional Block Diagram of the project

1.2 Design Alternatives

Other Face Detection Models:

- Consider alternatives like Haar Cascades or SSD for face detection if YOLO is too resource-intensive.

Other Emotion Recognition Models:

- Explore different CNN architectures or pre-trained models (e.g., VGG16 or ResNet) for improved accuracy in emotion classification.

1.3 Final Design

The final design integrates YOLO for face detection and a CNN model for emotion classification to provide a robust solution for real-time emotion recognition:

- Face Detection: YOLO is used to detect faces in video frames.
- Emotion Classification: A CNN model is used to classify emotions based on detected faces.
- Real-Time Processing: A computer or edge device processes video frames in real-time, displaying emotion classification results.

Chapter 3

Implementation details

3.1 Specifications and final system architecture

3.1.1 Specifications

3.1 Specifications and Final System Architecture

- YOLO (You Only Look Once): For efficient real-time face detection.
- CNN Model: For classifying emotions such as happy, sad, angry, etc.
- Camera: Captures live video feed for processing.
- Processing Unit: A computer or edge device capable of running real-time video processing and classification.

3.1.2 Final System Architecture

- Hardware Components:
  - Webcam/Camera: For capturing live video feed.
  - Computer/Edge Device: For processing the video frames and running face detection and emotion classification models.
  - YOLO (You Only Look Once): For real-time face detection.
  - CNN (Convolutional Neural Network): For emotion classification from the detected faces.
- System Connection:
  - The webcam captures a continuous video stream and feeds it to the computer.
  - YOLO performs face detection on each frame.
  - The detected faces are passed to a pre-trained CNN model to classify the emotions (e.g., happy, sad, angry).
  - The system continuously processes video frames in real-time and displays the emotion classification results on the user interface.
- Software Components:
  - YOLO: Used for detecting faces in the video frames.
  - CNN Model: A deep learning model (like VGG16, ResNet, etc.) is used to classify the emotions from the detected faces.
  - OpenCV: For handling video capture and frame processing.
  - TensorFlow/Keras: For running the pre-trained CNN model for emotion classification.
- This architecture ensures that the system can detect and classify emotions from faces in real-time video feeds, providing immediate feedback to the user.

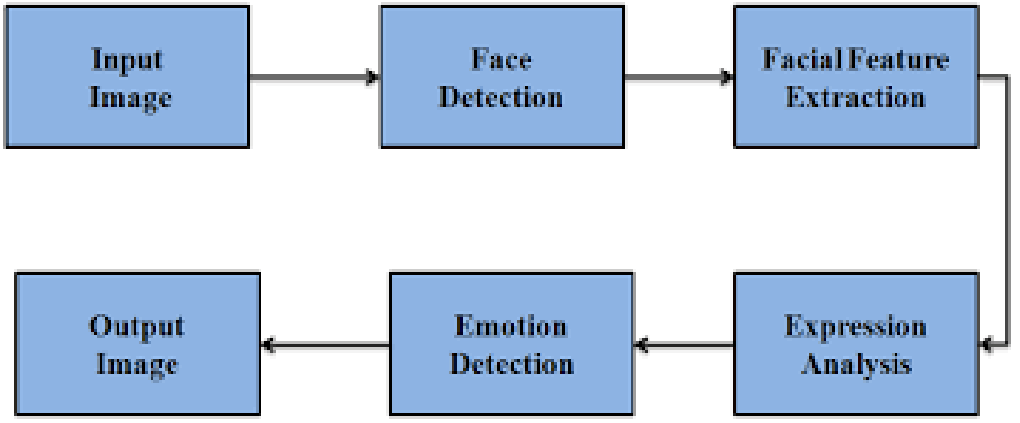
3.2 Algorithm

- **Hardware Setup**:
    - Connect a webcam to the computer for capturing video input.
    - Ensure the computer has the necessary processing power to handle real-time video analysis.
- **Install Software**:
    - Install Python and necessary libraries such as OpenCV, TensorFlow, and Keras.
    - Install YOLO model and emotion classification CNN model.
- **Face Detection (YOLO)**:
    - Capture video frames from the webcam using OpenCV.
    - Use YOLO to detect faces in each video frame. YOLO will return the coordinates of the bounding boxes around detected faces.
- **Emotion Classification (CNN)**:
    - Crop the detected faces from the frames.
    - Feed the cropped face images into the pre-trained CNN model for emotion classification.
    - Classify the emotions into categories like happy, sad, angry, surprised, etc.
- **Display Results**:
    - Use OpenCV to display the video feed with bounding boxes around the detected faces and overlay the predicted emotion label on each face.
- **Real-Time Processing**:
    - Continuously capture video, detect faces, classify emotions, and display the results in real-time.

3.3 Flowchart

Figure 3.1: Flowchart of the Real-Time Face Emotion Detection System

1. Start → Capture video frames from the webcam.
2. Detect Faces → Apply YOLO to detect faces in each frame.
3. Classify Emotion → Pass detected faces to the CNN for emotion classification.
4. Display Results → Show the video with bounding boxes around faces and overlay predicted emotions.
5. Repeat → Continue processing the next video frame in real-time.



Chapter 4

Optimization

4.1 Introduction to optimization

- **Optimization Strategies:**
- Energy Efficiency: Implementing efficient resource utilization and optimizing computational load ensures prolonged operation of the emotion detection system, particularly in scenarios requiring continuous monitoring and analysis.
- Threshold-based Alerting: By setting thresholds for detected emotion intensity, the system can send immediate alerts during critical emotional states, ensuring timely intervention or support.
- Remote Model Tuning: The ability to remotely update or fine-tune machine learning models ensures continued accuracy and reliability as emotional patterns or user profiles evolve over time.
- Data Transmission Optimization: Efficient data handling protocols, such as data compression or sending only significant insights, reduce network load and enhance system responsiveness.

4.2 Types of Optimization

4.2.1 Power Optimization:

- Optimize computational tasks to minimize power usage during emotional inference.
- Implement low-power modes for inactive hardware components.

4.2.2 Data Optimization:

- Reduce the frequency of data transmission by processing information locally and only sending critical insights.
- Batch process emotion data and send summarized results to reduce bandwidth usage.

4.2.3 Model Optimization:

- Regularly update and calibrate the emotion detection algorithms using recent datasets to maintain accuracy.

- Employ efficient algorithms or models suitable for real-time processing on resource-constrained devices.

4.2.4 Security Optimization:

- Secure all communications using strong encryption protocols to protect sensitive emotional data.
- Ensure robust access control mechanisms to safeguard user information and system operations.

4.2.5 Power Consumption Optimization:

- Use energy-efficient hardware components for emotional analysis tasks.
- Leverage power-saving modes for devices during periods of inactivity.

4.3 Selection and Justification of Optimization Method

In real-time emotion detection, optimization ensures efficient resource utilization, low latency, and accurate emotional insights. One key optimization method is leveraging local processing to reduce dependency on external servers, ensuring faster and energy-efficient operations.

4.3.1 Selection of Algorithmic Optimization

Optimizing the emotion detection system involves refining algorithms and improving efficiency to enhance performance. Consider the following techniques:

- **Model Compression:** Use techniques like pruning or quantization to reduce model size and enable faster processing.
- **Data Preprocessing:** Apply noise reduction techniques to raw data inputs, such as visual or auditory signals, to improve analysis accuracy.
- **Dynamic Inference:** Adjust the analysis frequency based on detected emotional changes or system activity, focusing resources when necessary.
- **Edge Processing:** Perform computations locally, reducing reliance on high-latency ex- ternal systems.

4.3.2 Justification

Algorithmic optimization is justified based on the specific requirements and characteristics of the real-time emotion detection system:

- **Cost-effectiveness:** Reducing external data processing minimizes operational costs and supports scalability.
- **Sustainability:** Efficient energy use and hardware optimization promote eco-friendly operations and extend device longevity.
- **User Experience:** Optimizations reduce system latency and enhance responsiveness, ensuring a seamless experience for real-time applications.

Algorithmic optimization is a strategic approach to improving the overall performance and usability of the real-time emotion detection system while meeting its specific goals and requirements.

Chapter 5

Results and Discussions

5.1 Result Analysis

Figure 5.1: Output

The system continuously monitors facial expressions or voice signals to detect emotions, displaying real-time results on a user interface. Thresholds for emotional intensity can be set in the algorithm, and notifications can alert users during critical emotional states.

5.1.1 Performance Metrics

- **Data Accuracy:** Evaluate the accuracy of detected emotions by comparing system out- puts with a manually labeled dataset or established emotional benchmarks.
- **Data Transmission:** Assess the speed and reliability of data transfer between the local processing unit and the user interface. Check for data loss or delays during transmission.
- **Response Time:** Measure the time taken from the detection of emotional cues to the display of results on the interface.
- **Power Consumption:** Monitor the power consumption of the system components and optimize for efficient usage.
- **Model Performance:** Track metrics like precision, recall, and F1-score to ensure the reliability of the emotion detection model over time.

5.1.2 User Feedback Analysis

Positive Feedback:

- **Real-time Monitoring:** Users appreciate the ability to monitor emotions in real-time, enabling immediate insights into emotional states.
- **Alert Notifications:** Users value the alert feature, which notifies them during intense or critical emotional events.

Negative Feedback:

- **Connectivity Issues:** Some users reported occasional connectivity issues between the system and the user interface, causing disruptions in real-time monitoring.
- **Model Calibration Challenges:** Ensuring consistent accuracy of the emotion detection model can be challenging for some users, especially with diverse emotional inputs.

5.2 Discussion on Optimization

5.2.1 Pre-Optimization

During this phase, the emotion detection model struggled with accuracy, frequently misclassifying emotions. The response time was higher, and power consumption was suboptimal.

5.2.2 Post-Optimization

After optimization, the emotion detection model achieved higher accuracy, significantly reducing misclassifications. The response time improved, and power consumption was optimized, ensuring better overall system performance. “‘

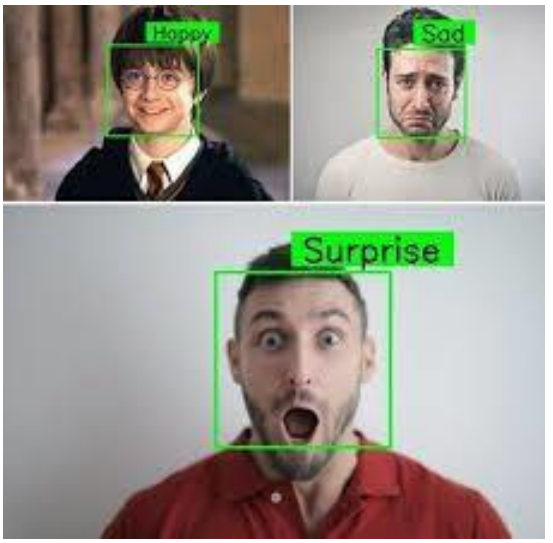


Figure 5.2: Pre-Optimization

Figure 5.3: Post-Optimization

Chapter 6

Conclusions and future scope

6.1 Conclusion

The real-time emotion detection project helps us understand human emotions by analyzing facial expressions, voice tones, or physiological signals. By leveraging advanced algorithms, we can gather insights about emotional states in real-time. This data is crucial for enhancing human-computer interaction, improving mental health monitoring, and creating empathetic technologies. The project supports individuals, organizations, and researchers in developing ap- plications that promote emotional well-being and effective communication.

6.2 Future Scope

The future scope of this project involves:

1. **Real-time Analysis:** Advanced algorithms enable real-time emotion detection, allowing for immediate understanding and response to emotional cues. This is crucial for applications such as mental health support and adaptive user interfaces.
2. **Improved Accuracy and Precision:** With the integration of advanced machine learning models, the system can achieve higher accuracy and precision in detecting a wide range of emotions, even in diverse and complex scenarios.
3. **Wide Applicability:** The scalability of emotion detection systems allows for integration across various domains, including healthcare, education, customer service, and entertainment, ensuring widespread impact and accessibility.
4. **Integration with Smart Systems:** Emotion detection can be incorporated into smart environments, such as homes and workplaces, to create adaptive systems that respond to the emotional states of users, enhancing comfort and efficiency.
5. **Public Awareness and Engagement:** Real-time emotion detection can be used to foster awareness about emotional well-being. By providing individuals with insights into their emotional states, the system can encourage actions that promote mental health and resilience.

In conclusion, the future scope of real-time emotion detection is promising, offering solutions for enhancing human-computer interaction, promoting emotional well-being, and supporting various innovative applications across industries. “‘

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