Software Requirements Specification

For

Instant feedback system (Using Face recognition)

Prepared by

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Revision History

Date	Change	Reason for Changes	Mentor Signature

INTRODUCTION

1.1 Purpose of the Project

The purpose of this project is to leverage advanced computer vision to enhance the services and experiences offered by various businesses, including restaurants, malls, art galleries, and transportation services. By deploying CCTV cameras equipped with face recognition, face recognition, and emotion recognition capabilities, this project aims to achieve the following objectives:

- **Face Recognition:** Face recognition allows us to recognize and follow the faces of certain people in CCTV camera-captured video. This can be used in a variety of situations, including tracking customer interactions and gauging visitor interest in art exhibits.
- **Face Recognition:** Face recognition technology will be incorporated into the system to recognize and identify people based on their face traits. This can be used to improve security, track returning clients, and customise offerings.
- **Emotion Recognition:** We intend to employ emotion recognition algorithms to analyze the face expressions of individuals. This will help in gauging customer satisfaction, employee performance, and viewer reactions in different settings.
- **Database Integration:** Our system will include a database component for saving reviews and related data, enabling businesses to analyze customer feedback and improve their services.

1.2 Target Beneficiaries

The primary beneficiaries of this project include:

- Restaurants: Restaurants can use the system to assess customer satisfaction in real-time, identify frequent diners, and improve service quality.
- Malls: Malls can utilize the technology to gauge shopper emotions, analyze foot traffic patterns, and optimize store layouts.
- Art Galleries: Art galleries can capture viewer reactions to specific artworks, helping curators understand which pieces are more engaging.
- Reception Areas: Businesses with reception areas can employ an instant feedback system to evaluate employee performance in responding to visitor inquiries.
- Transportation Services: In the context of transportation services, such as cabs, the system can be used to detect drowsy drivers and prevent accidents.

1.3 Project Scope

The scope of this project encompasses the following key functionalities:

- Implementation of face recognition, face recognition, and emotion recognition using Python libraries such as OpenCV, face_recognition, Keras, and numpy.
- Extracting frames (2D pictures) from video clips captured by CCTV cameras.
- Integration with a SQLite3 database for storing reviews and related data.
- Real-time analysis of face expressions to determine the emotional state of individuals.

1.4 References

The implementation of this project will rely on various Python libraries and technologies, including but not limited to:
- numpy
- OpenCV
- Keras
- face_recognition
- SQLite3
- Additionally, industry-specific best practices and guidelines for implementing face recognition and emotion recognition systems will be considered as references to ensure the ethical and responsible use of the technology.

PROJECT DESCRIPTION

2.1 Reference Algorithm

Convolutional Neural Network (CNN) for recognizing face and emotions : Convolutional Neural Networks' capacity to learn and extract significant elements from face photos makes them essential for face identification. They are especially well adapted for capturing the complexity of face geometry because to their hierarchical and weight-sharing architecture, which enables applications ranging from security to emotion recognition. The ethical and privacy issues raised by face recognition technology must be addressed, though.

Reference algorithm for Face recognition and emotion recognition includes:

1. Data Collection and Preprocessing:

Collect a dataset of labeled face images, including images of individuals displaying various emotions. Preprocess the images by resizing them to a consistent resolution, normalizing pixel values, and augmenting the dataset with transformations like rotation and flipping to increase diversity.

2. Model Architecture Design:

Design a deep CNN architecture that comprises several convolutional layers for feature extraction, followed by fully connected layers for classification.
For face recognition, the output layer should have as many neurons as there are individuals in the dataset, using softmax activation for multi-class classification.
For emotion recognition, the output layer should have neurons corresponding to the different emotions (e.g., happiness, sadness, anger), using softmax activation.

3. Model Training:

Train the face recognition model using the labeled dataset for individual identification.
Train the emotion recognition model using the labeled dataset for emotion recognition.
Utilize techniques like transfer learning if a pre-trained CNN model is available.

4. Model Evaluation:

Evaluate both models separately using appropriate metrics (metric such as accuracy , precision and F1 score) on a test dataset not used during training.

5. Real-Time Emotion Recognition (Optional):

Integrate the trained emotion recognition model with a webcam or camera feed for real-time emotion recognition.
Apply the model to video frames, capturing face expressions in real-time.

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6. User Interface (UI) Development:

Create a user-friendly UI that displays recognized individuals (in the case of face recognition) and recognized emotions (in the case of emotion recognition).
Provide options for users to interact with the system.

7. Security and Privacy Measures:

Implement security measures to protect the data and ensure responsible use of the technology, including user data privacy.

8. Testing and Validation:

Conduct thorough testing to validate the system's accuracy, robustness, and real-time capabilities.

9. Documentation:

Document the project comprehensively, including data collection, model architecture, implementation details, and user instructions.

10. Future Enhancements (Optional):

Consider future enhancements, such as multi-modal emotion recognition or expanding the system's capabilities.

11. Presentation and Reporting:

Prepare a presentation and report to communicate project objectives, methodology, results, and potential applications to stakeholders.

2.2 CHARACTERISTICS OF DATA

Dataset Characteristics:

- Size: The dataset consists of a total of X images of human faces, with each image having dimensions Y pixels in width and Z pixels in height.

- Labels: Each image in the dataset is associated with one or more labels, including individual identities for face recognition and emotion categories for emotion recognition (e.g., happy, sad, angry, surprised).

- Diversity: The dataset contains images of individuals from diverse ethnicities, age groups, and genders. It also covers a wide range of emotions expressed in various face expressions.

- Variability: The dataset includes variations in lighting conditions, face poses, and face expressions to ensure robust model training and testing.

- Imbalance: Emotion categories may exhibit some class imbalance, with certain emotions being less frequent than others. This is accounted for during data preprocessing.

- Secondary Source of Data:
  In addition to the primary data, supplementary data was obtained from publicly available datasets to augment the training dataset:

- FER-2013 (Face Expression Recognition 2013): This publicly available dataset includes a large number of face images labeled with seven different emotions. It provides diversity and helps increase the size of the dataset.

2.3 SWOT Analysis

Strengths (S):

1. Highly Relevant: Face recognition and emotion recognition are highly relevant in various fields, including security, healthcare, education, and human-computer interaction, addressing critical needs in these domains.

2. Advanced Technology: Leveraging Convolutional Neural Networks (CNNs) and deep learning techniques demonstrates the use of state-of-the-art technology to solve complex problems.

3. Wide Applicability: The project's outcomes can have broad applications, from improving security measures to enhancing user experiences in various technological domains.

4. Ethical Considerations: Addressing ethical and privacy concerns demonstrates a responsible approach to the development and deployment of face recognition technology.

Weaknesses (W):

1. Data Collection Challenges: Gathering a diverse and representative dataset for face recognition and emotion recognition can be time-consuming and resource-intensive.

2. Privacy Concerns: The use of face recognition technology raises privacy concerns, and addressing these concerns may require additional efforts in terms of system design and compliance.

3. Complexity: Developing and fine-tuning CNN models can be complex and may require expertise in deep learning and computer vision.

Opportunities (O):

1. Market Demand: The increasing demand for face recognition and emotion recognition technology presents opportunities for potential applications and commercialization.

2. Research Contribution: The project can contribute valuable research findings and datasets to the fields of computer vision, machine learning, and ethics in AI.

3. Innovation: There is room for innovation in improving the accuracy and robustness of face recognition and emotion recognition systems.

Threats (T):

1. Regulatory Changes: Evolving regulations related to face recognition technology may impose restrictions or compliance requirements that could affect project implementation.

2. Competitive Landscape: The field of face recognition is competitive, and keeping up with advancements and staying ahead of competitors may be challenging.

3. Privacy Advocacy: Continued advocacy for privacy and ethical use of face recognition technology may result in public resistance and calls for stricter regulation.

2.4 Project Features

The project involves the development of an Instant Feedback system that leverages face recognition and emotion recognition technologies to perform various functions:

1. **Video Frame Extraction:** The system will be capable of processing video clips, likely from CCTV cameras, and extracting individual frames or 2D pictures. This step is crucial for subsequent face expression analysis.

2. **Emotion-Based Experience Assessment:** By analyzing face expressions within these frames, the system will determine the emotional experiences of individuals in the video clips, categorizing them as favorable, negative, or neutral. This application can be used for security monitoring or customer satisfaction assessment, depending on the context.

3. **Art Gallery Viewer Engagement:** Cameras placed in art galleries will capture viewers' face expressions as they observe artworks. The system will use this data to assess which art pieces attract more attention based on viewer reactions.

4. **Driver Fatigue Recognition:** In vehicles, especially cabs, cameras will monitor the driver's face expressions to detect signs of drowsiness or fatigue. If the system identifies these signs, it will sound an alarm to alert the driver and enhance road safety.

5. **Visitor Inquiry Assessment:** At receptions, the system will evaluate how effectively employees respond to visitor inquiries by analyzing the visitors' face expressions and reactions. This feedback can help assess and improve customer service quality.

6. **Saving in database**: Doing some calculations and storing the Realtime reviews of the customers

Key benefits and applications of this system include enhancing security, monitoring viewer engagement in art galleries, improving road safety by preventing driver fatigue, and assessing and enhancing customer service quality in various settings. However, it is essential to consider privacy and ethical implications and ensure that the technology is used responsibly and in compliance with regulations.

2.5 Design and Implementation Constraints

- **Interfaces to other applications:**

  face_expression_model_structure.json
  face_expression_model_weights.h5

- **Specific technologies:**

  BERT

- **Tools to be used:**

  Jupyter Notebook

- **Language requirements:**
  Python:
  numpy
  Open CV
  keras
  face_recognition
  SQLite3
  marshal
  mathplotlib

2.6 Assumption and Dependencies

Assumed Factors:

1. Hardware Resources: Assumption that the project will have access to the necessary hardware resources, including GPUs or TPUs for training deep learning models and sufficient computing power for real-time processing.

2. Privacy and Legal Compliance: Assumption that the project will comply with privacy and legal regulations related to face recognition technology. Changes in privacy laws or ethical considerations could impact system requirements and data usage.

3. Camera Quality: Assumption that the quality and resolution of cameras used for video frame extraction and real-time analysis meet the system's requirements. Lower-quality cameras may affect the accuracy of face recognition and emotion recognition.

4. Lighting Conditions: Assumption that lighting conditions in the environments where the system is deployed are adequate for face analysis. Poor lighting conditions can lead to inaccuracies in face recognition and emotion recognition.

External Dependencies:

1. Regulatory Changes: Changes in privacy and face recognition regulations imposed by external regulatory bodies can necessitate updates to the system's requirements and compliance measures.

2. Hardware Procurement: Dependencies on the timely procurement of hardware resources, such as GPUs or specialized cameras, to support system development and deployment.

3. Ethical Considerations: The project may depend on ethical guidelines and considerations from external advisory boards or ethics committees, especially when dealing with sensitive data or real-world deployments.

4. External Testing Environments: If the system requires testing in real-world environments (e.g., art galleries, cars), the availability of these environments and cooperation from external stakeholders can impact testing and validation phases.

5. User Feedback: If user feedback is an integral part of system evaluation, dependencies on users' willingness to provide feedback and their availability for testing sessions.

6. Security Protocols: The project may rely on external security protocols or APIs for data encryption and user authentication, impacting the security requirements outlined in the SRS.

SYSTEM REQUIREMENTS

3.1 USER INTERFACE:

In the project focused on leveraging advanced computer vision for enhanced customer experiences through face recognition, recognition, and emotion analysis, several software components will require a user interface to facilitate interaction and control. Here are the key software components that would benefit from a user interface:

1. Face Recognition Module:
   - User Interface Purpose: To allow users to configure settings related to face recognition, such as sensitivity thresholds, regions of interest, and camera sources.
2. Face Recognition Module:
   - User Interface Purpose: Provide options for users to set up and manage face recognition databases, add new individuals, and perform recognition tasks.
3. Emotion Analysis Module:
   - User Interface Purpose: Enable users to fine-tune emotion analysis algorithms, set confidence thresholds for emotion predictions, and visualize real-time emotion results.

3.2 SOFTWARE INTERFACE:

In THIS project, the various modules interact to create a seamless system for face recognition, recognition, emotion analysis, and customer feedback management. Here's a description of the connections between the modules, the services needed, and the nature of communications:

1. Face Recognition Module:
   - Connections: This module interfaces with the CCTV cameras to capture video feeds. It communicates with the Face Recognition Module to pass detected faces for further processing.
   - Services Needed: Access to video feeds from CCTV cameras, real-time video processing capabilities.
   - Communication: Real-time video frames are passed to the Face Recognition Module for further analysis.
2. Face Recognition Module:
   - Connections: This module interacts with the Face Recognition Module to receive detected faces for recognition. It also interfaces with the Database Management Module to query and update the face recognition database.
   - Services Needed: Access to face images for recognition, database services for storing and querying face data.
   - Communication: It receives detected faces from the Face Recognition Module, processes them for recognition, and updates the database with new face data.
3. Emotion Analysis Module:
   - Connections: This module receives face images from the Face Recognition Module to analyze emotions. It may also interface with the Database Management Module to log emotion data.
   - Services Needed: Access to face images for analysis, real-time processing capabilities for emotion recognition.
   - Communication: It receives face images, analyzes them for emotions, and may log emotion data in the database.

3.3 DATABSE INTERFACE:

A Database Management System (DBMS) plays a crucial role in storing, organizing, and managing the data related to customer feedback, face recognition, and emotion analysis. Here's an explanation of the DBMS used in your project:
Database Management System: SQLite3

- Explanation:
  - SQLite3 is a lightweight, serverless, self-contained SQL database engine that is widely used in embedded systems and applications where a full-scale database management system is not necessary. It's suitable for projects like yours where there's a need for efficient data storage and retrieval, but without the complexities of a larger DBMS.

3.4 PROTOCOLS:

In this project focused on leveraging advanced computer vision for enhanced customer experiences through face recognition, recognition, and emotion analysis, several requirements are associated with the protocols deployed. Here's an overview of the key requirements:
1. Communication Protocol (TCP/IP or HTTP/HTTPS):
- Requirements:
  - Reliability: The protocol must ensure reliable data transmission between modules to avoid data loss or corruption.
  - Low Latency: Real-time data processing demands a low-latency communication protocol to provide timely feedback and updates.
  - Error Handling: The protocol should have mechanisms to detect and recover from transmission errors to maintain data integrity.
  - Efficiency: It should minimize overhead to maximize the efficiency of data transmission.

NON-FUNCTIONAL REQUIREMENT

Non-functional requirements are categorized into three categories:

Performance Requirements
Security Requirements
Software Quality Attributes:

4.1 Performance requirements

- **Real-time Processing:** The project must achieve real-time face recognition and emotion recognition, with a response time of no more than 100 milliseconds. This means that when a user interacts with the system, it should be capable of processing the face image and delivering feedback almost instantaneously. Achieving this level of responsiveness is crucial for providing a seamless and natural user experience.
- **Scalability:** The system should be designed to handle a scalable number of users and concurrent requests. This scalability requirement ensures that the system can accommodate a growing user base and maintain its performance under high loads. It should be able to efficiently allocate resources and process requests in parallel to prevent bottlenecks during peak usage.
- **Resource Efficiency:** The application should be optimized for resource efficiency, minimizing CPU and memory usage. This optimization is essential to ensure that the system operates smoothly on a wide range of hardware configurations. Efficient resource utilization also contributes to lower operational costs and better user experiences.
- **Accuracy:** The face recognition and emotion recognition accuracy should be above 90%. This requirement emphasizes the importance of the system's ability to accurately interpret face expressions. High accuracy ensures that the feedback provided to users is meaningful and reliable, contributing to user trust and satisfaction.
- **Minimum Hardware Requirements:** The project must specify the minimum hardware specifications required for running the system smoothly. This includes detailing CPU, GPU, and RAM requirements. By defining these hardware prerequisites, you ensure that users are aware of the system's technical demands and can plan their hardware accordingly.

Meeting these performance requirements will be essential for delivering a responsive, accurate, and efficient system that can handle varying workloads and provide valuable feedback to users in real-time. Properly addressing these aspects during the development and testing phases will help ensure the project's success in meeting its performance goals.

4.2 Security Requirements and Software quality attribute:
- Data Privacy:
- Data Encryption: All user data, including face images and any personal information, must be securely encrypted during transmission and while at rest. This encryption ensures that even if unauthorized access occurs, the data remains unreadable.
- Compliance with Regulations: Ensure that the project complies with relevant data privacy regulations, such as GDPR or HIPAA, depending on the application domain. This includes obtaining proper user consent and handling sensitive data in accordance with legal requirements.

- Data Retention Policies: Implement data retention policies that specify how long user data is stored and when it should be securely deleted. This prevents unnecessary data exposure and reduces the risk of data breaches.
- Authentication and Authorization:
- User Authentication: Implement strong user authentication mechanisms, such as multi-factor authentication (MFA) or biometric authentication, to ensure that only authorized individuals can access the system.
- Role-Based Access Control (RBAC): Employ RBAC to define and manage user roles and permissions within the system. This restricts access to sensitive functions and data to authorized personnel only.
- Session Management: Implement secure session management to prevent session hijacking and enforce user session timeouts to mitigate the risk of unauthorized access.
- Data Access Control:
- Access Logs: Maintain detailed access logs that record all user interactions with the system. These logs should include information about who accessed what data and when.
- Audit Trails: Implement audit trails for critical system actions, enabling the tracking of changes made to user data and system configurations.
- Data Masking: Implement data masking techniques to protect sensitive information in logs and reports, ensuring that confidential data is not exposed unintentionally.
- Protection Against Cyber Threats:
- Intrusion Recognition and Prevention: Deploy intrusion recognition and prevention systems (IDPS) to monitor network traffic and system activities for signs of unauthorized access or malicious activities.
- Firewall Protection: Employ robust firewall configurations to control incoming and outgoing network traffic, protecting the system from external threats.
- Regular Security Audits: Conduct regular security audits and vulnerability assessments to identify and address potential weaknesses in the system's defenses.
- Secure Communication:
- Secure Protocols: Ensure that all data transmitted between the user and the system is encrypted using secure communication protocols such as HTTPS, TLS, or SSH.
- Certificate Management: Implement proper certificate management practices to maintain the integrity of SSL/TLS certificates and ensure they are up-to-date.