

**T.C.**

**MARMARA UNIVERSITY**

**FACULTY of ENGINEERING**

**COMPUTER ENGINEERING DEPARTMENT**

CSE4197 Engineering Project 1

PROJECT SPECIFICATION DOCUMENT

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Title of the Project

**FaceApp**

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**1. Problem Statement**

This project aims to tackle privacy issues associated with sharing group photographs on messaging applications. In response to concerns such as excluding individuals from shared photos and potential discomfort, particularly in school or family contexts, our goal is to develop a user-friendly, privacy-focused group photograph sharing application. Objectives include eliminating unwanted photos and ensuring privacy by preventing images from reaching unrelated individuals. The project's significance lies in providing a solution that enhances user privacy and experience. Expected outcomes encompass a user-friendly mobile app, a robust facial recognition system, secure data sharing, resulting in increased satisfaction and reduced privacy concerns.

**2. Problem Description and Motivation**

**2.1 Problem Context**

In today's digital age, the pervasive nature of group photographs shared across messaging applications has led to an emerging concern: privacy. Individuals captured in group photographs often face scenarios where:

* Photographs are disseminated indiscriminately, including individuals do not present in the photo.
* Concerns arise when photographs are accessible to unrelated individuals within the same chat group, potentially compromising the privacy of individuals depicted in the photos.

**2.2 Motivation**

The motivation behind this project is deeply rooted in addressing these prevalent privacy challenges associated with group photograph sharing. Our motivation stems from several critical reasons:

*2.2.1 User-Centric Approach*

Our primary motivation is to provide a user-centric solution. Users, especially within school groups or family chat environments, deserve the confidence that their privacy is safeguarded when sharing group photographs.

*2.2.2 Privacy and Sensitivity*

The sensitivity of individual privacy, especially concerning children and families, necessitates a solution that ensures that shared photographs are only accessible to relevant individuals present in the image.

**2.3 Potential Impact**

Successful execution of this project is anticipated to bring about the following impacts:

* **Enhanced Privacy:** Users will have improved privacy control over their shared group photographs, addressing concerns about unwanted photo distribution.
* **User Satisfaction:** The creation of a user-friendly and privacy-focused application will lead to increased user satisfaction and trust.

**3. Main Goal and Objectives**

**3.1 Main Goal**

The overarching goal of this project is to develop a comprehensive privacy-focused group photograph sharing application that addresses the privacy concerns associated with group photographs shared within various messaging applications. Our aim is to provide a user-centric, secure, and efficient platform that empowers users to share group photos confidently and privately.

**3.2 Objectives**

In pursuit of the main goal, we have established specific objectives to guide our project development. These objectives are clear, measurable, and attainable and collectively contribute to the successful realization of the main goal:

*3.2.1 Project Objective 1: Creation of a User-Friendly Chat Application*

* **Description:** Develop a user-friendly chat application tailored for mobile platforms using Flutter and Dart technologies.
* **Rationale:** A user-friendly chat application is the foundation of the project, providing the environment in which users share photographs and interact.

*3.2.2 Project Objective 2: Implementation of Facial Recognition*

* **Description:** Implement a facial recognition system, employing the OpenCV library and Python, to accurately classify individuals in group photographs.
* **Rationale:** Accurate facial recognition is the core feature that allows us to identify individuals in photos and ensure privacy.

*3.2.3 Project Objective 3: Development of a Secure Data Sharing System*

* **Description:** Create a secure data sharing system that allows users to share photographs only with individuals present in the photo.
* **Rationale:** The secure sharing system is the cornerstone of privacy protection, ensuring that only authorized users can access shared photographs.

*3.2.4 Project Objective 4: Compliance with Professional Standards*

* **Description:** Adhere to professional engineering standards and best practices throughout the project, ensuring the use of version control with Git/GitHub, Gantt charts for project management, and Object-Oriented Programming principles.
* **Rationale:** Professional standards and practices enhance project organization, collaboration, and code quality.

**4. Related Work**

In this section, we review and compare existing research and solutions related to privacy issues in group photograph sharing applications. A thorough understanding of related work is crucial for identifying gaps and novelties in our project.

**4.1 Existing Solutions**

Several existing solutions and applications address privacy issues in group photograph sharing, with a focus on user privacy and data security. Notable examples include:

*4.1.1 WhatsApp and Telegram*

* **Privacy Features:** Both WhatsApp and Telegram have implemented privacy features like end-to-end encryption and group-specific settings.
* **Limitations:** While these applications provide some level of privacy, they may not address the issue of sharing photographs only with individuals present in the photo.

*4.1.2 Facial Recognition Applications*

* **Applications:** Some facial recognition applications enable users to tag individuals in photos, offering a level of personalization.
* **Limitations:** These applications often require manual tagging and do not address privacy concerns related to photo sharing with unauthorized users.

**4.2 Research in Privacy Protection**

Several research studies have delved into privacy protection in photo sharing, particularly in social media settings:

*4.2.1 Privacy-Preserving Photo Sharing*

* **Research:** Studies in privacy-preserving photo sharing have explored cryptographic techniques to protect images from unauthorized access.
* **Limitations:** These solutions may not always offer seamless user experiences and can be complex for non-technical users.

*4.2.2 Facial Recognition in Photo Tagging*

* **Research:** Facial recognition research has advanced in the context of photo tagging on social media platforms.
* **Limitations:** These solutions are often oriented towards improving user experiences but may not address concerns specific to group photograph sharing privacy.

**4.3 Project Novelties**

Compared to the related work, our project introduces several novelties and differentiators:

* **Automated Facial Recognition:** Our project focuses on automating facial recognition to classify individuals in group photographs, reducing the need for manual tagging.
* **Privacy-Centric Approach:** We prioritize user privacy and security by ensuring that photographs are shared only with individuals present in the photo, addressing concerns related to unauthorized access.
* **Integration of Chat and Facial Recognition:** The combination of chat functionality with facial recognition sets our project apart, offering a holistic solution for privacy-focused group photograph sharing.

**5. Scope**

The scope of this project encompasses the development of a privacy-focused group photograph sharing application with a multifaceted approach. It includes the following components:

**5.1 Chat Application**

* Creation of a user-friendly chat application for the mobile platform using Flutter and Dart technologies.
* Integration of chat functionalities, including text messaging, multimedia sharing, and group creation [2].

**5.2 Facial Recognition System**

* Implementation of a facial recognition system using the OpenCV library in Python.
* Accurate classification of individuals present in group photographs.
* Detection of unique facial features and characteristics to identify individuals.

**5.3 Data Sharing Features**

* Development of a system that enables users to share photographs securely.
* Ensuring that photos are shared only with individuals who are part of the image.
* Protection of personal data and prevention of unauthorized access to shared photos.

**5.4 Constraints**

The project operates within defined constraints and assumptions, including:

* **Economic Constraints:** Limitation of messaging feature since we are planning to use spark plan (free) of Firebase.

**5.5 Assumptions**

The project is based on several key assumptions, including, but not limited to:

* Assumption of a manageable number of simultaneous users for optimal system performance.
* Assumption of compatible network infrastructure to handle bandwidth requirements.
* Assumption that the project design will be suitable for its intended purpose.

**6. Methodology and Technical Approach**

The methodology and technical approach for this project encompass a comprehensive plan to achieve the specified objectives and deliver a privacy-focused group photograph sharing application. This section provides a detailed breakdown of our approach, including the technologies, tools, and methods we intend to employ.

**6.1 High-Level Solution Approach**

Our high-level solution approach involves several key phases:

*6.1.1 Chat Application Development*

We will develop the chat application for the mobile platform using Flutter and Dart. These technologies offer cross-platform compatibility and an efficient development process. Upon entering the application, users will be expected to take and upload a photo of themselves to facial recognition feature to work. Later, they will be able change that photo.

*6.1.2 Facial Recognition*

For the main feature of the project, which is facial recognition, we will utilize the OpenCV library in conjunction with Python. The primary objective is to accurately classify individuals in group photographs. This will involve detecting and distinguishing facial features to identify and differentiate users.

*6.1.3 Secure Data Sharing*

To ensure privacy, we will implement secure data sharing mechanism. Photographs will only be shared with individuals who are present in the photo, and personal data will be protected.

**6.2 Theory and Algorithms**

Our algorithm for sharing a media with any group is as shown in Figure 1:

metin, ekran görüntüsü, diyagram, yazı tipi içeren bir resim

Açıklama otomatik olarak oluşturuldu

Figure 1: Media sharing algorithm

*6.2.1 OpenCV Algorithms*

*6.2.1.1 Bayes Classifier:*

* The Bayes Classifier is a probabilistic algorithm that leverages Bayes' theorem to make predictions based on input features. In the context of facial recognition, it aids in the classification of individuals by analysing patterns in facial features and determining the likelihood of a match (see Figure 2) [9].

(1)

*P(c|x): Posterior Probability*

*P(x|c): Likelihood*

*P(c): Class Prior Probability*

*P(x): Predictor Prior Probability*

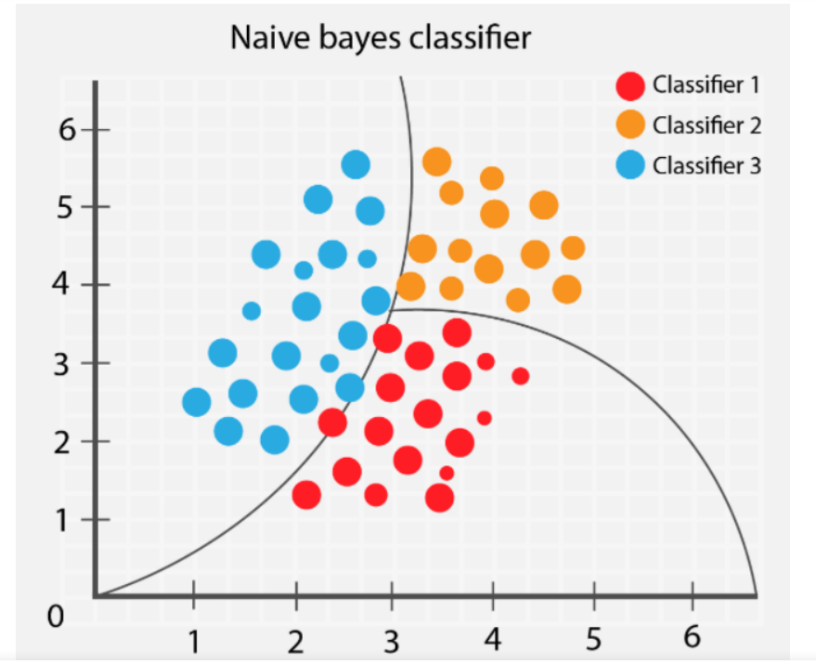
**

Figure 2: Bayes classifier

*6.2.1.2 K-Nearest Neighbors (KNN):*

* K-Nearest Neighbors is a proximity-based algorithm that classifies data points based on the characteristics of their nearest neighbors. In our project, KNN can be employed to identify facial features by comparing them to the features of individuals in the training dataset, contributing to accurate user classification (see Figure 3) [8].

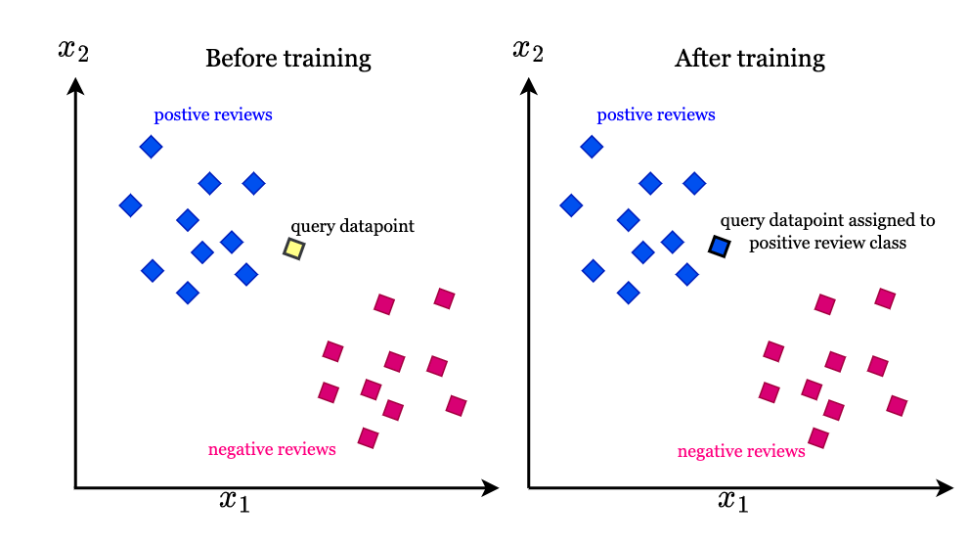


Figure 3: K-Nearest Neighbours

*6.2.1.3 Support Vector Machines (SVM):*

* Support Vector Machines are powerful classifiers used for both regression and classification tasks. SVMs create a hyperplane that effectively separates data points into distinct classes. In facial recognition, SVMs can aid in distinguishing and classifying facial features with high precision. (Figure 4)

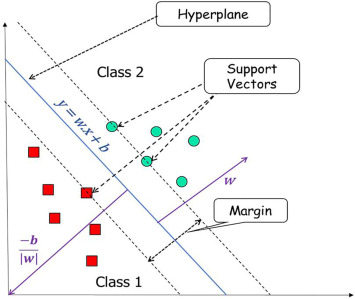


Figure 4: Support Vector Machines

*6.2.1.4 Decision Trees:*

* Decision Trees are tree-like structures that recursively divide the data based on attribute values. In facial recognition, decision trees can be utilized to navigate through facial features, making decisions at each node to accurately classify individuals present in group photographs (see Figure 5) [3].

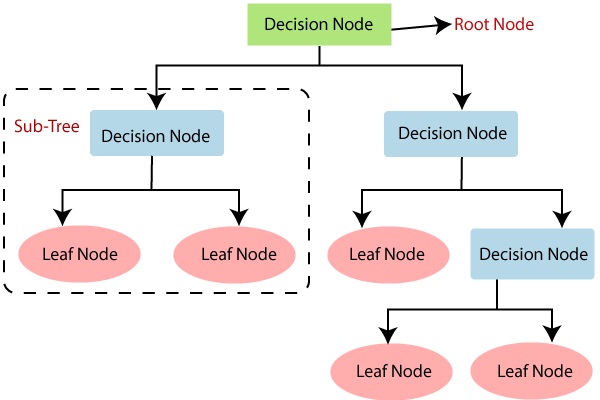


Figure 5: Decision Tree

*6.2.1.5 Neural Networks:*

* Neural Networks are deep learning models inspired by the human brain's structure. In our project, they can be employed for complex pattern recognition in facial features. Neural Networks are adaptive and can enhance the accuracy of identifying individuals, contributing to the overall effectiveness of our facial recognition system. (Figure 6)



Figure 6: Neural Networks

**6.3 Performance Evaluation**

Performance evaluation is a critical aspect of this project, and we will employ the following measures:

* **Accuracy:** We will assess the accuracy of the facial recognition system in correctly identifying individuals.
* **Response Time:** Measurement of the system's response time when handling image recognition and data sharing.
* **Resource Utilization:** Monitoring the efficient use of system resources, including memory and processing power.

**6.4 Resource Requirements**

To ensure the successful execution of the project, a comprehensive set of resources is imperative. The project will necessitate the following resources across hardware, software, and human capital domains:

*6.4.1 Hardware Resources*

* **Mobile Devices for Testing and Development:**
  + The project will require access to a range of mobile devices for testing the developed application across various platforms and screen sizes.
  + Emulators will be employed to simulate different device environments, aiding in comprehensive testing and development.

*6.4.2 Software Resources*

* **Development Tools:**
  + **Flutter and Dart:**
    - Flutter and Dart will serve as the primary technologies for developing the mobile application [4].Flutter provides a robust framework for cross-platform development, ensuring consistency across different operating systems [10].
  + **Python and OpenCV:**
    - Python, coupled with the OpenCV library, will be utilized for the implementation of the facial recognition system. OpenCV offers versatile tools for image processing and computer vision, aligning with the project's core feature.
  + **Firestore SDK:**
    - The Firestore SDK, integrated with Flutter, will facilitate real-time data synchronization and storage. Firestore, being a NoSQL cloud database, aligns with the project's mobile platform requirements [5].
  + **Integrated Development Environments (IDEs):**
    - Visual Studio Code and Android Studio will be the primary IDEs for coding, testing, and debugging. Visual Studio Code offers a lightweight and versatile environment, while Android Studio caters specifically to Android application development.
  + **Firebase Services:**
    - Utilizing Firebase services, including authentication and cloud functions, will enhance the application's functionality and security [11].

**7. Professional Considerations**

In this section, we address various professional considerations and standards that will guide the project's development, collaboration, and overall management.

**7.1 Methodological Considerations and Engineering Standards**

*7.1.1 Version Control with Git/GitHub*

* **Version Control:** We will utilize Git as our version control system and host our code repositories on GitHub. This practice ensures code integrity, collaboration, and easy tracking of project changes.
* **Commit Conventions:** Our team will adhere to clear and descriptive commit messages, following a consistent convention (e.g., Semantic Versioning) for effective code review and history tracking.

*7.1.2 Gantt Charts*

* **Project Management:** Gantt charts will be employed to visualize project timelines, task dependencies, and milestones. This aids in effective project management and allows for the tracking of progress against established deadlines.

*7.1.3 Object-Oriented Programming (OOP)*

* **Code Structure:** We will follow the principles of Object-Oriented Programming to create modular and maintainable code. Classes, objects, inheritance, and encapsulation will be employed to enhance code organization and reusability [6].
* **Design Patterns:** We will explore design patterns like Singleton, Factory, and Observer to solve recurring design problems and promote code flexibility and scalability[7].

**7.2 Realistic Constraints**

*7.2.1 Economic Constraints*

* **Budget Adherence:** We will manage the project following the limitations of spark plan of Firebase.

*7.2.2 Environmental Constraints*

* **None:** We are not planning to see any environmental constraints for our project.

*7.2.3 Ethical Constraints*

* **Privacy and Security:** Protecting the privacy and security of users and their data is of utmost importance. We will adhere to ethical guidelines in data handling and access control.

*7.2.4 Health and Safety Constraints*

* **User Safety:** We will consider the health and safety of users and the public when designing the application, particularly in scenarios involving potential stress factors or sensitive information.

*7.2.5 Sustainability Constraints*

* **Product Reliability:** Ensuring that the application is reliable and durable under normal operation conditions to support its long-term sustainability.

*7.2.6 Social Constraints*

* **Respectful Design:** We will avoid designing products that may negatively profile specific races, genders, or any group of individuals.

**7.3 Legal Considerations**

*7.3.1 Permissions and Licensing*

* **Compliance:** We will ensure compliance with all necessary legal permissions and licenses, especially if the developed product is intended for market release.
* **Data Protection:** Legal considerations will extend to data protection and privacy regulations to safeguard user information.

**8. Management Plan**

The management plan for this project outlines the strategies, responsibilities, and timelines to ensure the successful execution of the privacy-focused group photograph sharing application. The plan encompasses various aspects of project management, including task phases, responsibilities, and milestone tracking.

**8.1 Task Phases and Durations**

The project will progress through distinct task phases, each with its specific objectives and activities. The estimated durations for each phase are as follows:

*8.1.1 Phase 1: Chat Application Development*

* **Duration:** Approximately 3 months
* **Description:** During this phase, the primary focus is on the development of the chat application using Flutter and Dart technologies.

*8.1.2 Phase 2: Facial Recognition System*

* **Duration:** Approximately 2 months
* **Description:** This phase concentrates on implementing the facial recognition system, which is the core feature of the project.

*8.1.3 Phase 3: Secure Data Sharing*

* **Duration:** Approximately 2 months
* **Description:** The third phase focuses on the development of a secure data sharing system that ensures the privacy of users.

**8.2 Division of Responsibilities**

Effective delegation and division of responsibilities among team members are crucial for a smooth project management process. The roles and responsibilities within the project team are defined as follows (Figure 7):

*8.2.1 Chat Application Interface*

* **Team:** Emirhan Erdoğan – Eren Başpınar
* **Role:** Responsible for the development of frontend part of the chat application using Flutter and Dart technologies.
* **Responsibilities:** User interface design and testing.

*8.2.2 Chat Application Functionality*

* **Team:** Emirhan Erdoğan – Alper Özdemir
* **Role:** Responsible for the development of backend part of the chat application using Flutter, Dart and Firebase technologies.
* **Responsibilities:** Chat functionality implementation and testing.

*8.2.3 Facial Recognition Feature*

* **Team:** Emirhan Erdoğan – Eren Başpınar – Alper Özdemir
* **Role:** Focuses on implementing the facial recognition system using the OpenCV library and Python.
* **Responsibilities:** Model training, algorithm development, and integration with the chat application.

*8.2.4 Quality Assurance and Testing*

* **Team:** Eren Başpınar – Alper Özdemir
* **Role:** Responsible for quality assurance and testing at various stages of the project.
* **Responsibilities:** Identifying and reporting bugs, testing application performance, and providing user feedback.

Figure 7: Contributions table

**8.3 Timeline with Milestones**

The project timeline includes well-defined milestones to track progress and ensure that the project stays on course. A Gantt chart will be utilized to visualize the project timeline effectively. The following are some key milestones:

*8.3.1 Milestone 1: Chat Application Prototype*

* **Due Date:** February 2024
* **Description:** Completion of the chat application prototype, including user interface design and essential chat functionalities.

*8.3.2 Milestone 2: Functional Facial Recognition System*

* **Due Date:** May 2024
* **Description:** Successful implementation of the facial recognition system, capable of accurately identifying individuals in group photographs.

*8.3.3 Milestone 3: Secure Data Sharing System*

* **Due Date:** June 2024
* **Description:** Completion of the secure data sharing system, ensuring that photographs are shared only with relevant individuals.

**8.4 Project Time Line (Gantt Chart)**

The distribution of all stages by month, from the beginning to the end of the project, is shown in Figure 8.

**

Figure 8: Monthly planning table

**9. Success Factors and Risk Management**

In this section, we will delve into the critical success factors that are pivotal to the accomplishment of our project objectives, as well as the risk management strategies designed to anticipate, assess, and mitigate potential obstacles.

**9.1 Success Factors**

Identifying success factors is essential for achieving the project's objectives. The following factors play a significant role in the success of our privacy-focused group photograph sharing application:

*9.1.1 Project Objective 1: Creation of a User-Friendly Chat Application*

Success Factor for Objective 1:

The success of our chat application's technical performance will be measured through key metrics focusing on the efficiency and reliability of the system. We aim to achieve low message delay, targeting a message delivery time of under 2 seconds in normal network conditions. Additionally, interface usability will be assessed by ensuring smooth and responsive UI interactions with a high frame rate and minimal lag. These technical benchmarks are crucial in ensuring the application's robustness, efficiency, and reliability, thereby enhancing the overall user experience.

*9.1.2 Project Objective 2: Implementation of Facial Recognition*

Success Factor for Objective 2:

The accuracy and efficiency of our facial recognition system will serve as the primary KPI. We aspire to achieve a recognition accuracy of no less than 90%, measured by comparing the system's identifications with manually labelled ground truth data. Additionally, the system's response time for recognizing individuals in group photographs should be under 2 seconds, ensuring a seamless user experience.

*9.1.3 Project Objective 3: Development of a Secure Data Sharing System*

Success Factor for Objective 3:

The success of our secure data sharing system will be evaluated based on its ability to limit photo access to authorized individuals. Our KPI involves achieving a 98% accuracy in ensuring that shared photographs are only accessible to individuals present in the image.

*9.1.4 Project Objective 4: Compliance with Professional Standards*

Success Factor for Objective 4:

Adherence to professional standards will be gauged through systematic evaluations. Our KPIs include maintaining a high Git commit convention adherence, with at least 90% of commits following the established conventions. Additionally, the completion of project milestones as per the Gantt chart and successful integration of Firebase services should align with industry best practices.

**9.2 Risk Management Plan**

The risk management plan outlines strategies for identifying, assessing, mitigating, and monitoring potential risks and challenges that may arise during the development of the privacy-focused group photograph sharing application.

*9.2.1 Risk Identification*

Risk identification involves the process of recognizing potential risks that may impact the project. The following are some key risks specific to this project:

*9.2.1.1 Technical Risks*

* **Facial Recognition Accuracy:** The accuracy of the facial recognition system may fall short of expectations, resulting in misidentifications.
* **Integration Challenges:** Challenges in integrating the facial recognition system with the chat application may lead to delays and compatibility issues.
* **Performance Issues:** The application's performance, including response time and resource utilization, may not meet user expectations.

*9.2.1.2 Privacy and Security Risks*

* **Privacy Concerns:** Users might have concerns about the privacy of their facial recognition data or shared photos, potentially affecting adoption.

*9.2.1.3 Team-Related Risks*

* **Skill Gaps:** Insufficient expertise in facial recognition, mobile app development, or data security among team members may slow progress.
* **Team Conflicts:** Internal conflicts within the development team could hinder collaboration and productivity.

*9.2.1.4 External Risks*

* **Legal and Compliance Issues:** Changes in data protection and privacy laws or compliance requirements could impact project implementation.

*9.2.2 Risk Assessment*

For each identified risk, we will assess its potential impact and likelihood. Risks will be categorized as low, medium, or high based on the following criteria:

* **Impact:** Assess the potential consequences of the risk on the project's objectives, including timeline and quality.
* **Likelihood:** Evaluate the probability of the risk occurring, considering historical data, industry standards, and expert opinions.

*9.2.3 Risk Mitigation*

To address identified risks, we will implement mitigation strategies to reduce their impact or likelihood. Here are some examples of risk mitigation strategies:

*9.2.3.1 Technical Risks*

* **To address facial recognition accuracy:**
* Employ rigorous testing processes.
* **To manage integration challenges:**
* Allocate additional time for integration and compatibility testing.
* Maintain open communication channels with the team.

*9.2.3.2 Privacy and Security Risks*

* **To address privacy concerns:**
* Clearly communicate privacy policies and provide users with data control options.

*9.2.3.3 Team-Related Risks*

* **To overcome skill gaps:**
* Provide training and resources for team members to acquire required skills.
* **To manage team conflicts:**
* Promote open and transparent communication.

*9.2.3.4 External Risks*

* **To address legal and compliance issues:**
* Stay informed about changes in data protection laws and regulations.

*9.2.4 Risk Monitoring and Reporting*

Regular risk monitoring is essential to track the effectiveness of mitigation strategies and identify new risks as the project progresses. The following processes will be in place:

* **Risk Reviews:** Periodic reviews will be conducted to assess the status of identified risks, their impact, and the effectiveness of mitigation strategies.
* **Reporting:** Risks, their current status, and any adjustments to mitigation plans will be reported to the project manager and relevant stakeholders.

**10. Benefits and Impact of the Project**

**10.1 Benefits/Implications**

The implementation of our privacy-focused group photograph sharing application yields a plethora of benefits and implications for both end-users and the broader digital community. By meticulously examining these facets, we gain a nuanced understanding of the positive outcomes and broader effects our project can engender.

Our innovative application ensures that users experience heightened privacy and control over their shared content, addressing longstanding concerns related to unwanted photo distribution. Parents, friends, and individuals valuing their privacy will find our solution invaluable in creating a secure and personalized environment for group photograph sharing. The implications extend beyond individual users to impact group dynamics positively, particularly in sensitive contexts such as school groups, social gatherings, and family events.

**10.2 Scientific, Economic, Commercial, Social Impact**

Our project carries significant impact across scientific, economic, commercial, and social dimensions, showcasing its transformative potential in diverse realms.

• **Scientific Impact:** The integration of automated facial recognition technology into social applications marks a scientific leap. By automating facial recognition to classify individuals in group photographs, our project significantly reduces the reliance on manual tagging, streamlining user experience.

• **Economic Impact:** The creation of a user-friendly, privacy-focused application contributes to economic growth by enhancing user satisfaction and trust. A robust application has the potential to attract a broad user base, creating economic opportunities through user engagement, potential premium features, and partnerships.

• **Commercial Impact:** In the commercial landscape, our application stands out by merging chat functionality seamlessly with facial recognition. This innovative approach opens avenues for unique advertising and collaboration possibilities, positioning the application as a distinct offering in the market.

• **Social Impact:** Addressing privacy concerns in group photograph sharing contributes to positive social interactions. Users gain greater control over their shared content, fostering a sense of empowerment and security within online communities. Our project aligns with evolving societal expectations for responsible data sharing practices.

**10.3 Potential Impact on New Projects**

Our project is poised to set new standards and inspire innovation in future endeavours within the digital interaction landscape.

• **Technological Innovations:** The incorporation of automated facial recognition into the realm of social applications is a technological leap, setting a precedent for more intuitive and secure photo-sharing experiences. Future projects may draw inspiration from our user-centric approach and privacy-focused features.

• **User Experience Design:** The emphasis on user experience design, particularly in the context of group photograph sharing, can serve as a benchmark for future projects aiming to balance functionality with privacy considerations. The success of our intuitive design may encourage similar approaches in subsequent applications.

**10.4 Impact on National Security**

While the primary focus of our project is individual privacy within digital interactions, we acknowledge the broader implications for national security considerations.

• **Ethical Data Handling:** By upholding ethical standards in data handling and access control, our project indirectly contributes to national security. The responsible management of user data aligns with broader considerations of protecting sensitive information in the digital age [1].

• **Preventing Unauthorized Access:** The secure data sharing system implemented in our application plays a role in preventing unauthorized access to shared photos. This aspect aligns with broader security measures and considerations for protecting information within the national context.

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